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HENRY WOODWARD, LL.D., F.R.S., V.P.Z.S.,
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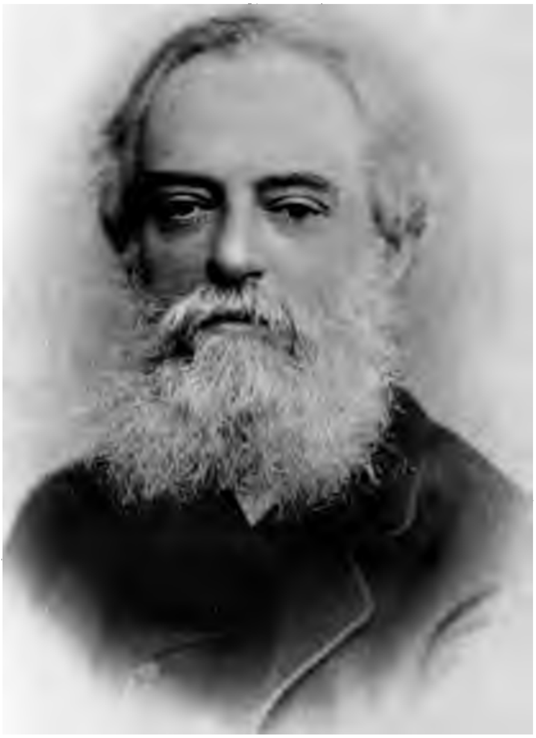

W. T. Blanford.

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No. I.—JANUARY, 1905.

ORIGINAL ARTICLES.

I.—Eminent Living Geologists:

William Thomas Blanford, C.I.E., LL.D., F.R.S., V.P. Zool. Soc., Treas. Geol. Soc.

(WITH A PORTRAIT, PLATE I.)

WHAT India has been in the past 300 years to our Army as a nursery in which our soldiers have obtained experience in their profession and earned their promotion, often to the highest rank, such in a lesser degree has it been to many of our geologists, who have, in the past much shorter period of 50 or 60 years, entered the service in this vast field of scientific enterprise, and, aided by a very few amateur geologists in the Army and of civilians attached to other branches of Government employ, have covered many thousand square miles of our Indian Empire with records of their untiring energy in the geological field.

Among the amateurs may be recorded the names of Generals Sir Richard Strachey and Sir Proby T. Cautley, Dr. Hugh Falconer, Lieut-Gen. C. A. McMahon; and as professional geologists, Dr. T. Oldham, H. B. Medlicott, J. G. Medlicott, Dr. Wm. King, Dr. Valentine Ball, the two Blanfords, W. Theobald, R. Bruce Foote, A. B. Wynne, C. L. Griesbach, R. D. Oldham, F. R. Mallet, C. S. Middlemiss, T. D. La Touche, Dr. F. Stoliczka, Professor W. Waagen, the present Director (T. H. Holland), and many others.

Prominent among the earlier geological workers stand out the names of the brothers W. T. and H. F. Blanford, who joined the Indian Survey together in 1855. Having served on the staff for seven years, the younger left in 1862, being appointed to the Educational service, and subsequently as head of the newly constituted Meteorological Department for India, a post which he held until 1888, when he retired, and died in 1893 (see notice of his life and work, Geol. Mag., 1893, pp. 191–2).

William T. Blanford, the surviving brother, and the subject of the present memoir, was born on 7th October, 1832, at 27, Bouverie Street, Whitefriars, in the City of London. The house and manufactory adjoining it belonged to his father, William Blanford, the whole having been built and established by him. This house, with some others adjoining it, and also the manufactory, now form the printing and publishing offices of the *Daily News*.

W. T. Blanford received his early education in private schools at Brighton, and afterwards in Paris. He was sent to Paris at the age of 14, and remained there till March, 1848, just after the Revolution. He happened to be laid up during that critical time in January with a severe bronchial attack, doubtless diphtheria, and was in bed during the eventful change of government from the rule of Louis Philippe to the temporary government by the National Assembly. He suffered for a considerable time from results of this illness, and passed two years with a mercantile house at Civita Vecchia, in the Roman States (then occupied by the French), the head of the firm being an old friend of his father's.

Returning to England in 1851, he joined his father's business, but his younger brother, Henry, having meantime matriculated at the Royal School of Mines, which had opened in that year, the temptation to abandon business and take up a scientific career was too strong, and he followed his brother and entered the Laboratory under Lyon Playfair in 1852 and matriculated in October of that year. The course was only for two years, and both brothers passed out at the head of the list, each having carried off the Duke of Cornwall's and the Council Scholarships. The vacations were spent by the brothers in studying field-geology with Professor (afterwards Sir A. C.) Ramsay, and mining in Cornwall with Professor (afterwards Sir W.) Warington Smyth; one Autumn being passed in travelling in Norway.

Besides Lyon Playfair (afterwards Lord Playfair), Ramsay, and Warington Smyth, Edward Forbes lectured on Natural History, and Percy was Professor of Metallurgy; these were the principal teachers in the School of Mines in 1852–4, of which Sir Henry T. De la Beche was the Director. Huxley joined the staff towards the end of the time, and W. T. Blanford had the advantage of hearing one or two of his earlier lectures.

After leaving the School of Mines in 1854, a year was passed at Freiberg in Saxony in the study of chemistry, mineralogy, mining, and metallurgy. Before this year came to an end, the brothers were offered and accepted posts on the Geological Survey of India, under Dr. Thomas Oldham, F.R.S., the then Superintendent. They sailed for India in the late Summer, and arrived in Calcutta at the end of September, to find that Dr. Oldham was away with Colonel Phayre's mission to the Court of Ava, and no information of their appointment had been received by any Government official. There was no Survey office at that time, and it was only by chance the brothers met Mr. W. Theobald, a member of the Survey staff. There were no telegraphs in those days, and posts were slow, so that nearly two months elapsed before hearing from Dr. Oldham. Part of the time was spent in a visit to the Raniganj Coalfield, and in the study of Hindustani. On Dr. Oldham's return to Calcutta in December everything was arranged, and in January, 1856, a party nsisting of W. T. and H. F. Blanford, with Mr. Theobald, was spatched to examine and report on a coalfield near Talchir, about miles north-west of Cuttack in Orissa.

This survey had some important geological results. The coal as found to be abundant, though of very inferior quality, but the st steps in the classification of the Indian coal-bearing rocks were ken in the separation of a lower division called Talchir, and of higher group, provisionally classed as Mahadeva, from the coal-aring beds themselves, to which the name Damuda series was ven by Dr. Oldham. This subdivision proved the key to the assification of the great series of formations subsequently named e Gondwána system. Another and even more interesting discovery as the occurrence of large boulders in fine silt in the Talchir strata, d it was suggested that the boulders had reached their present sition by the agency of ice, a view which, although long regarded doubtful, has in the course of the last thirty years been abundantly nfirmed by discoveries of a similar formation of like geological e in many parts of India, in Australia, South Africa, and South merica, and by ample evidence of a glacial origin for these erratics.

Returning to Calcutta in May, the Blanfords were ordered to rjiling for the monsoon months. The next year (1857) they re separated, the younger brother being left in charge of the ice then established in Calcutta, whilst W. T. Blanford accompanied . Oldham during the working season 1856–7 in a survey of the jmahal Hills. During the latter part of the time W. T. Blanford amined the country to the westward of the Rajmahal Hills, and turned to Calcutta in May, 1857, just at the moment when the utiny broke out at Delhi. He had actually ridden down part of e Grand Trunk Road through the discharged sepoys of the 2nd renadiers, whose regiment had just been disbanded at Barrackpore, d one of the last officers he had seen in the district traversed was few days later murdered by his men at Deoghur.

Dr. Oldham left shortly afterwards for England, where he was cupied on official work till nearly the end of the year. Henry lanford went to Madras at the head of a Survey party, and W. T. lanford was left in charge of the Survey and offices throughout e Mutiny year. He joined at this time the Calcutta Volunteer valry Guards, a corps who were of much use in preserving the ace of mind of the residents in Calcutta, but were never called on to take the field.

The year 1857–8 was occupied in a survey of the Orissa coast-nd, but few districts in the interior of Northern India were fficiently settled after the Mutiny to be safe for small parties to vel in. The seasons 1858–9 were mainly devoted to a complete rvey of the Raniganj Coalfield, the most important source of al in India. The ground had been previously surveyed by r. D. H. Williams,[1] Dr. Oldham's predecessor, but the whole of the

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[1] Mr. D. H. Williams was formerly attached to the Geological Survey of Great itain under De la Beche, and surveyed large areas of the South Wales Coalfield.

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to mode of origin, to the relation of organisms to physical conditions, and to the question of contemporaneity.

In his second address his wide knowledge of geology and natural history was brought to bear on the much debated subject of the permanence of ocean basins; and after reviewing the evidence with great skill and judgment, he concluded "that whilst the general permanence of ocean basins and continental areas cannot be said to be established on anything like firm proof, the general evidence in favour of this view is very strong. But there is no evidence whatever in favour of the extreme view accepted by some physicists and geologists that every ocean bed now more than 1,000 fathoms deep has always been ocean, and that no part of the continental area has ever been beneath the deep sea. Not only is there clear proof that some land areas lying within continental limits have at a comparatively recent date been submerged over 1,000 fathoms, whilst sea-bottoms now over 1,000 fathoms deep must have been land in part of the Tertiary era, but there are a mass of facts both geological and biological in favour of land-connection having formerly existed in certain cases across what are now broad and deep oceans."

Both addresses are pervaded by a philosophical spirit which commands our admiration, and both may be profitably read and re-read at the present day.

One who is well acquainted with Mr. Blanford and his work writes:—"As regards Blanford's views on ocean basins and old land surfaces, they have been advocated with great skill, backed by an immense experience, and seem to be in conformity with Lyellian doctrines. One important feature in Blanford's career is the way in which he has been enabled to combine geography with geology. No one can have been said to have done so much to harmonize the sister sciences, and the prominent positions he has held, from time to time, in the Geological and Geographical Societies have enabled him to give effect to his views in both connections. Together with this insight into the physical aspects of geology he combines extensive zoological knowledge, as more especially evinced by the works which he has produced or edited for the Government of India and in this country. His work in every department, whether in zoology, geography, or geology, has been marked by thoroughness and accuracy."

As already stated, Mr. Blanford received the Wollaston Medal in 1883, immediately after his final return from India, and a Royal Medal from the Royal Society in 1901 in special recognition of his work on the Geology and the Fauna of British India.

In 1904 he received from H.M. the King the Companionship of the Indian Empire.

He is an Honorary Member of the Asiatic Society of Bengal, the Hungarian Geological Society, and the American Ornithologists' Union, and a Corresponding Member of the Isis, Dresden, and the Belgian Geological Societies.

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1854. "On a Section lately exposed in some Excavations at the West India Docks": Journ. Geol. Soc., x, pp. 433–435.

1856. (With Messrs. H. F. Blanford and Wm. Theobald, jun., Geological Survey of India) "On the Geological Structure and Relations of the Talcheer Coalfield in the District of Cuttack": Mem. Geol. Surv. India, i, pp. 33–88.

1859. "Note on the Laterite of Orissa": Mem. Geol. Surv. India, i, pp. 280–294.

1860. "On the Rocks of the Damúda Group, and their Associates in Eastern and Central India, as illustrated by the Re-examination of the Ránigánj Field": Journ. As. Soc. Bengal, xxix, pp. 352–358.

1860–1. (With Mr. H. F. Blanford) "Contributions to Indian Malacology": Journ. As. Soc. Bengal, xxix, pp. 117–127, and xxx, pp. 347–367.

1861. "Note on the Geological Structure and Relations of the Ránigánj Coalfield, Bengal": Mem. Geol. Surv. India, iii, pp. 1–195.

1861. "Note on a Species of *Plectopylis*, Benson, occurring in Southern India": Ann. Nat. Hist., vii, pp. 244–246.

1862. "Contributions to Indian Malacology, No. 3: Descriptions of new Operculated Land-Shells from Pegu, Arakan, and the Khasi Hills": Journ. As. Soc. Bengal, xxxi, pp. 135–144.

1862. "Account of a Visit to Puppádoung, an Extinct Volcano in Upper Burmah": Journ. As. Soc. Bengal, xxxi, pp. 215–226; Rep. Brit. Assoc., pt. ii, pp. 69–70.

1863. "On Indian Species of Land-Shells belonging to the genera *Helix*, Linn., and *Nanina*, Gray": Ann. Nat. Hist., xi, pp. 81–86.

1863. "On the Animals of *Raphaulus*, *Spiraculum*, and other Tube-bearing Cyclostomacea": Ann. Nat. Hist., xii, pp. 55–58.

1863. "Descriptions of *Cremnobates Syhadrensis* and *Lithotis rupicola*, two new Generic Forms of Mollusca inhabiting Cliffs in the Western Ghats of India": Ann. Nat. Hist., xii, pp. 184–187.

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1864. "On the Classification of the Cyclostomacea of Eastern Asia": Ann. Mag. Nat. Hist., xiii, pp. 441–465.

1865. "Contributions to Indian Malacology, No. 5: Descriptions of New Land-Shells from Arakan, Pegu, and Ava, with Notes on the Distribution of Described Species": Journ. As. Soc. Bengal, xxxiv, pt. 2, pp. 66–105.

1865. "On the Manner of Occurrence of the Reptilian Remains found in the Panchet Beds of the Raniganj Coalfield, and on the probable conditions existing at the time when these rocks were deposited" [1865]: Pal. Ind. (Pret. Vert.), i, 1865–85 (pt. 1), pp. i–iii.

1865. "On the Stratigraphy and Homotaxis of the Kota-Maledi (Maleri) Deposits" [1878]; Pal. Ind. (Pret. Vert.), i, 1865–85 (pt. 2), pp. 17 (*bis*)–23.

1866. "Contributions to Indian Malacology, No. 6: Descriptions of New Land-Shells from the Nilgiri and Anamullay Hills and other places in the Peninsula of India": Journ. As. Soc. Bengal, xxxv, pt. 2, pp. 31–42.

1866. "Contributions to Indian Malacology, No. 7: List of Species of *Unio* and *Anodonta* described as occurring in India, Ceylon, and Burma": Journ. As. Soc. Bengal, xxxv, pt. 2, pp. 134–155.

1866. "On *Opisthostoma*, H. Blanford, with the Description of a New Species from the Neighbourhood of Bombay, and of the Animal and Operculum (*O. Fairbanki*)": Proc. Zool. Soc., pp. 447–451.

1867. "Descriptions of some Indian and Burmese Species of *Assiminea* (*A. cornea*, *A. subconica*, *A. marginata*, *A. rotunda*, *A. rubella*)": Ann. Mag. Nat. Hist., xix, pp. 381–386.

1867. "Stone Implements found in Central India": Proc. As. Soc. Bengal, pp. 136–138, 144–145.

1867. "Rediscovery of Franklin's *Certhia spilonota* (*Salpornis silonota*, Gray)": Ibis, iii, pp. 461–464.

1867. "On a New Species of *Callene* from the Pulney Hills in Southern India (*C. albiventris*, Fairbank)": Proc. Zool. Soc., pp. 832–834.

1867. "Note on the Geology of the Neighbourhood of Lynyan and Runneekote, north-west of Kotree, in Sind": Mem. Geol. Surv. India, vi, pp. 1–15.
1867. "On the Geology of a portion of Cutch": Mem. Geol. Surv. India, vi, pp. 17–38.
1868. "Description of *Fairbankia bombayana*, a new genus and species of Rissoidæ from Western India": Ann. Mag. Nat. Hist., ii, pp. 399–401.
1868. "Contributions to Indian Malacology, No. 8: List of Estuary Shells collected in the Delta of the Irawady in Pegu, with Descriptions of New Species": Journ. As. Soc. Bengal, xxxvi, pt. 2, pp. 51–72.
1868. "Zoological Notes": Journ. As. Soc. Bengal, xxxvi, pt. 2, pp. 189-200.
1868. "Contributions to Indian Malacology, No. 9: Descriptions of New Diplommatinæ from Darjiling and the Khasi Hills": Journ. As. Soc. Bengal, xxxvii, pt. 2, pp. 77–83.
1868. "Natural History Notes made on a Voyage to Abyssinia": Proc. As. Soc. Bengal, pp. 65–66.
1868. "On the Zoology, etc., of Abyssinia": Proc. As. Soc. Bengal, pp. 83–86.
1868. "Notes on Abyssinia": Proc. As. Soc. Bengal, pp. 167–174.
1868. "Notes on a Journey in Northern Abyssinia": Proc. As. Soc. Bengal, pp. 276-287.
1868. "Monographie du genre *Cyathopoma*": Journ. de Conchyl., xvi, pp. 256–263.
1868. "Note sur les *Nicida*, section subgénérique des Diplommatina habitant la Péninsule de l'Inde": Journ de Conchyl., xvi, pp. 330–336.
1869. "On the Animal and Operculum of *Georissa*, W. Blanf., and on its Relations to *Hydrocena*, Parreyss; with a Note on *Hydrocena tersa*, Bens., and *H. milium*, Bens.": Ann. Mag. Nat. Hist., iii, pp. 173–179.
1869. "Notes on some Indian and Mascarene Land-Shells": Ann. Mag. Nat. Hist., iii, pp. 340–344.
1869. "Descriptions of five Birds (*Hirundo æthiopica*, *Ruticilla* (?) *fuscicaudata*, *Phylloscopus habessinicus*, *Alauda prætermissa*, *Crithagra flavivertex*), and a Hare (*Lepus tigrensis*), from Abyssinia": Ann. Mag. Nat. Hist., iv, pp. 329–330.
1869. "Contributions to Indian Malacology, No. 10: Descriptions of New Species of Cyclophoridæ, of *Ennea* and *Streptaxis*, from the Hills of Southern and South-Western India": Journ. As. Soc. Bengal, xxxviii, pt. 2, pp. 125–143; Proc. As. Soc. Bengal, pp. 65–67.
1869. "Ornithological Notes, chiefly on some Birds of Central, Western, and Southern India": Journ. As. Soc. Bengal, xxxviii, pt. 2, pp. 164–191; Proc. As. Soc. Bengal, pp. 104–105.
1869. "On the Fauna of British India, and its Relations to the Ethiopian and so-called Indian Fauna": Rep. Brit. Assoc., xxxix (sect.), pp. 107–108.
1869. "On the Traps and Inter-Trappean Beds of Western and Central India": Mem. Geol. Surv. India, vi, pp. 137-162.
1869. "On the Geology of the Taptee and Lower Nerbudda Valleys and some Adjoining Districts": Mem. Geol. Surv. India, vi, pp. 163–384.
1869. "Descriptions of New Land and Fresh-water Molluscan Species collected by Dr. John Anderson in Upper Burma and Yunan": Proc. Zool. Soc., pp. 444–450.
1869. "On the Species of *Hyrax* inhabiting Abyssinia and the Neighbouring Countries": Proc. Zool. Soc., pp. 638-642.
1869–70. "On the Geology of a portion of Abyssinia": Quart. Journ. Geol. Soc., xxv, pp. 401–406; Phil. Mag., xxxix, p. 389.
1870. "On *Georissa*, *Acmella* (*Cyclostoma tersum*, Bens.), *Tricula*, and *Cyathopoma millium*, Bens.": Ann. Mag. Nat. Hist., vi, pp. 368–370.
1870. "Contributions to Indian Malacology, No. 11: Descriptions of New Species of *Paludomus*, *Cremnoconchus*, *Cyclostoma*, and of Helicidæ, from various parts of India" [1869]: Journ. As. Soc. Bengal, xxxix, pt. 2, pp. 9–25.
1870. "Notes on some Reptilia and Amphibia from Central India": Journ. As. Soc. Bengal, xxxix, pt. 2, pp. 335–376; Proc. As. Soc. Bengal, pp. 254–257.
1870. "On Faults in Strata": GEOL. MAG., vii, pp. 115–118.
1870. "List of Birds obtained in the Irawadi Valley around Ava, Thayet Myo, and Bassein": Ibis, vi, pp. 462–470.

1870. "On the Coal Seams of the Tawa Valley, Baitool District, Central Provinces" [1868]: Rec. Geol. Surv. India, i, pp. 8–11.

1870. "On the Coal Seams of the Neighbourhood of Chanda" [1868]: Rec. Geol. Surv. India, i, pp. 23–26.

1870. "Notes on the Route from Poona to Nagpur *viâ* Ahmednuggur, Jalna, Loonar, Yeotmahal, Mangali, and Kingunghat" [1868]: Rec. Geol. Surv. India, i, pp. 60-65.

1870. "Note on the Lead Vein near Chicholi, Raipûr District": Rec. Geol. Surv. India, iii, pp. 44–45.

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II.—ON THE FORMATION OF A SPECIES.

By JOHN FRANCIS WALKER, M.A., F.L.S., F.G.S., etc.

THE object of this communication is to try to give a theory of what takes place when one species is changed into another. When the species A is converted into the species B there must be an intermediate transitional stage in which the collection of individuals is neither the species A nor the species B. I have already defined a species as a centre round which individuals are thickly clustered, and the spaces between these centres may be either devoid of individuals or contain here and there an abnormal form (Davidson's "Suppt. Jurassic Brachiopoda," Pal. Soc., 1876, p. 122).

This idea may be expanded thus:—The true type of a species is its centre, where the individuals are most thickly clustered and most closely resemble each other; those further from the centre differ less or more widely from the type as they approach nearer the boundary of the species.

As a species moves, either in geographical space or geological time, the position of its centre will gradually alter, if its environment be different, so that forms like those contained near the boundary of the species A, and therefore not typical of it, may become the centre of the species B and typical of it. The specimen first figured, the so-called type of a species, may be characteristic of it if it happens to be an individual near the centre of the species, but it is not so if it is a specimen near the boundary of the species; a named figured specimen is only a fixed point.

The so-called species are of unequal value; they may have been named from an abnormal form of growth, or from an immature specimen in which the characters have not been fully developed, or from one of unusual size, or from a badly preserved specimen in which the characters are obscure. Many of the older species have been made into subgenera, and these again divided into species. The difference between a species and a variety is that the species is more permanent, being in a state of stable equilibrium.

I have stated (Davidson's "Suppt. Jurassic Brachiopoda," p. 180) that it is advisable to give a name to a well-marked variety when it is constantly found in a given geological horizon, although it may be connected by rare forms with other species, and also for the purpose of limiting the extent of variation of a form bearing the same name, so that there can be no doubt which variety is referred to when it is stated to occur in a certain district.

Species can be made to appear to have been joined together by selecting the abnormal forms out of thousands of specimens and neglecting the percentage of normal ones. The abnormal form of one species may be the normal form of another species. The true centre of a species may be found by collecting from a given locality a very large number of specimens and observing the percentage of the different forms. The greatest number of individuals closely resembling each other will indicate the centre of the species at that locality. It will be found that no two individuals are exactly alike, but the amount of variation of those which form the bulk of the collection is infinitesimal; these are the centre of the species, whilst the rarer forms differ from the typical specimens, and are therefore further from the centre of the species. The conversion of one species into another must be gradual, as a sudden change would probably make the species extinct, as it would require time to adapt itself to the conditions which alter its form. Great and sudden alterations in form tend to weaken an individual so that it seldom survives; this serves to check rapid variation.

The tendency of variation in a species is also checked by their interbreeding with each other, and probably the power of variation during a limited time is not great without exhausting the species. The susceptibility to the influence of environment will vary in different individuals: some will be able to alter their form and adapt themselves to the new conditions, others will scarcely be able to alter and will become gradually extinct.

The rate of variation in individuals may be different, and give rise to new species: thus, the species A may develop two or more points nearer its circumference where individuals differing from the typical form begin to thickly cluster, and so give rise to new centres, the percentage of the normal form of the species A becoming gradually less; these centres, if isolated from each other, will give rise to new species. The spaces between different centres of species are unequal, owing to missing species which have not yet been discovered.

The duration of the life of a species will depend on the length of time it exists under the same conditions; the longer it does so the less it will vary, as it will have gradually acquired the most favourable form for its environment, and therefore all variations will be less favourable and have less chance of surviving. This will account for the greater length of time the Palæozoic species existed compared with the Mesozoic species, as the seas would have greater extent and be less broken up by land.

III.—Rock Cavities in Granite in Madagascar.

By the Rev. Richard Baron, F.L.S., F.G.S., Tananarive, Madagascar.

I WAS much interested in the account of the 'erosion' of rocks in Corsica given by Mr. Tuckett and Professor Bonney respectively in the January and August numbers of the Geological Magazine for 1904, more especially as I have been long acquainted with similar phenomena in Madagascar, and have, equally with the authors mentioned, been long puzzled to find an explanation of their origin at all satisfactory.

Perhaps a brief statement of the occurrences of such rock 'erosion' in the form of cavities as I have met with in Madagascar may be worthy of a place in the Magazine, as being another small contribution to the subject.

I shall first of all give, in very few words, a description of the rock in which the cavities occur, and then proceed to a short account of a few of the most striking of the cavities themselves.

The rock (apparently a boss) in which these cavities occur is porphyritic granite, occupying, roughly speaking, a circular area of, say, fifteen or sixteen miles in diameter, and weathering, as granite usually does, into small and large, more or less rounded or oval-shaped hills, which are scattered all over the surface. The western edge of the mass is some ten or twelve miles to the east of Antananarivo, the capital of the island.

The rock is, strictly speaking, a porphyritic hornblende-granitite (i.e. hornblende-biotite-granite). In colour it is grey, blotched, and streaked with black. Fully three-fourths or four-fifths of its bulk is felspar. This occurs in the form of porphyritic crystals, the longest of which attain sometimes two inches in length. The felspar includes orthoclase-microperthite (pure orthoclase is apparently quite absent, or at any rate rare), microcline, and another plagioclase (? oligoclase); these exist in not very unequal proportions. The felspars often show the central accumulation of extremely minute dusty particles, more frequently seen perhaps in more basic rocks (gabbros and norites especially). Micropegmatite, as well as ordinary quartz-felspar mosaic, occurs as a coating round some of the grains. Both the felspar and the quartz (the latter with abundant planes of gas and liquid inclusions) show signs of some amount of molecular strain. The mica is ordinary brown biotite, and the amphibole ordinary green hornblende. These occur in irregular flakes and grains, but are often so intimately associated as to lead to the supposition that the one has been derived from the other.

As accessory minerals, occur sphene (pretty abundant), magnetite (often intergrown with iron pyrites), apatite, zircon, and calcite, possibly also a few minute garnets.

The porphyritic felspars often show a slight fluxional arrangement. The rock, except superficially, is quite fresh, and at the localities where the cavities occur the weathering has not proceeded further, neither in depth nor degree, than in other places.

The above is a brief description of the granite in which the cavities to be described are found. It must be remembered, however, that many more cavities are known than those here mentioned, and that all these together doubtless form but a very small fraction of those which exist throughout the granitic area.

The first hole I shall describe is situated in the middle of a perpendicular face of rock some two-thirds of the way up one of the high hills close by the village of Alarobia. The lower edge of the hole is 8 or 10 feet above the foot of the rock, and cannot be reached without the aid of a small ladder or other contrivance. The rock at its surface is somewhat weathered, but not more so than in other places. The entrance is nearly round, and some 5 or 6 feet in diameter. Inside, from the roof downwards, the hole measures 12 feet, the width is 10, and the depth inwards and horizontally from the entrance is 9. It is in part divided into two portions by a projecting ridge; these two portions are together roughly separated into eight rounded divisions; and these again into some three dozen smaller ones, the average being more than sufficient to contain a man's head. The walls are not smooth, and not specially weathered; in fact, they are much the same as the rock outside. A white powder may be seen here and there on the surface, which, possessing an alkaline taste, may be a potash salt derived from the felspar.

At the foot of the hill there is a fallen rock, in the face of which are two holes, each about the size of a very large straw beehive.

Another hole is to be found on the east side of the mountain of Ambohibory, about half-way up. The entrance is about 4 ft. high by 2 ft. 6 in. in width, and of a rounded shape, like that of the large cavity mentioned above. The interior measures 5 ft. 2 in. from the roof downwards; from the mouth inwards to the back is 4 ft.; the direction at right angles to this being 4 ft. 10 in. The wall of the cavity contains thirteen or fourteen rounded depressions.

On the same hill, a little farther south, is to be found another but smaller cavity. Its dimensions are as follows: height 1 ft. 6 in., horizontal diameters 3 ft. by 3 ft. 10 in. There are two entrances near to each other, one 2 ft. 4 in. wide by 1 ft. 9 in. high, the other 1 ft. wide by 1 ft. 6 in. high. In the interior there are three or four nest-like depressions.

Not far away, on the same side of the hill, there is another cavity having a comparatively small entrance (about 2 ft. by 2 ft.). The height of the interior is about 3 ft., its breadth from right to left 2 ft., and its depth from the mouth inwards 5 ft. 5 in. In the wall are six or eight smaller cavities.

There is another hole a few yards further south on the under side of an overhanging mass of granite. Though it is small, it contains three or four basin-shaped depressions. Other cavities exist further south.

On the mountain of Ambohitsileo there are several other cavities, one of which is probably larger than any of those mentioned above.

On the north side of the mountain of Angavokely there is also a large cavity.

It stands to reason that if in the course of two or three comparatively short rambles so many rock cavities should be found, a further acquaintance with the granitic area would probably reveal the existence of others in large numbers.

How, then, are these rock-holes to be accounted for? I have known of their existence for many years, but they had practically passed out of my mind until I came across the articles in the GEOLOGICAL MAGAZINE for 1904. The explanation of their formation which always occurred to me when I thought about them was that they represented what were originally nests of felspar, which had since decayed and disappeared. I have, however, always felt the explanation to be unsatisfactory, and for the following reasons:—(1) Though segregations of the more basic minerals (often taking the form of true diorite) are quite common in the granite, segregations of felspar (except here and there in veins) I have never come across. I do not, of course, say that there are none such. (2) Felspar nests can hardly be supposed to have had in all cases the remarkably rounded outlines and the rounded protuberances on the surface which the cavities, such as I have described, seem to require. (3) If these holes really represent nests of felspar which have rotted out and disappeared, it is difficult to account for the felspar crystals on the present walls of the cavities remaining comparatively fresh; and (4) it is difficult to see by what process, on this supposition, the decayed felspar has been so cleanly scooped out of the holes.

The theory that these numerous cavities have been eroded by the action of wind-carried sand cannot possibly account for them, at any rate in the area I am speaking of, for the simple reason that there is no sand anywhere near worth speaking of, and sand-laden winds are unknown in the interior of the island. Moreover, would not sand-abrasion produce striæ round the walls? The theory on the face of it seems far-fetched. Abrasion of plain surfaces by blown sand in the open country is quite explicable, but that the sand-laden wind (supposing sand to be present) should gyrate and bore at particular points sufficiently long or frequently to produce these remarkable cavities seems to me entirely incredible.

"Nor," as Professor Bonney says, "does the action of dew or of moisture in any form seem a promising explanation, for," etc.

If, then, these rock cavities are due neither to the decay and disappearance of knots or nests of felspar, nor to erosion by blown sand, nor to the action of "dew or moisture in any other form," how are they to be accounted for?

I make bold to suggest an explanation, to which at present I can see no objection, and which, at any rate, would account for the phenomena; it *is that these cavities represent spaces* occupied by *imprisoned vapours in the original rock magma.* We know what an important rôle the occlusion of gas and liquid bubbles plays in individual minerals; to how large an extent bubbles, many of them gigantic, of steam and other gases rise from the depths to the surface during volcanic activity; and how also solidified lava is frequently riddled with rounded vesicles, the former receptacles of imprisoned gas. Is it therefore improbable that the hot vapours in certain deep-seated magmas, instead of being entirely absorbed, have, in certain parts and under certain conditions, so pushed aside the viscous mass by their expansive force as to form larger or smaller vesicles? And, further, is there any reason against the supposition that some of these spaces have been occupied by several bubbles, for a time at least, in juxtaposition, though separated probably by partitions of the magmatic material? The existence of protruding ridges (which are sometimes present) would seem to support such a view, the remaining walls having broken down and disappeared. If this hypothesis be correct, it would seem to follow that these gas cavities, or some of them, must have existed during at least the closing stages of the solidification of the rock; in other words, from the time that the rock was still sufficiently viscous to permit of being pushed aside by the expansive power of the vapour, until it had hardened to a degree sufficient to prevent the collapse of the walls of the cavities. Whether previously the whole of the gas was equally dispersed throughout the rock mass, or whether part of it had accumulated here and there into bubbles, I do not pretend to say. The diminution of pressure during the final stages of solidification would probably also allow of the increased expansion of the imprisoned gases. It would also follow that, as denudation proceeded at the surface of these rock masses, fresh cavities should continually come to the surface, and that this is the case seems to be shown by the smallness of the entrance to some of the holes (Professor Bonney speaks of one only two inches in diameter),[1] entrances which would naturally widen until the hole would become more or less basin-shaped, and finally disappear.

What are the miarolitic spaces and drusy cavities which not unfrequently are to be found in plutonic rock masses? Are these in every case due to contraction on crystallization of the rock material, or may they not be sometimes owing to the expansion of localized vapour? If the latter, these rock cavities may be nothing more than miarolitic spaces or druses.

It is in consequence of the improbability of the production of these rock cavities by any form of superficial action suggested or apparently conceivable that I have been led to the above hypothesis as their efficient cause. What are the objections to it?

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[1] Mr. Baron has forgotten that this little hole was merely one of communication between two adjacent cavities, the inner of which had one of ordinary size lower down.—Ed. Geol. Mag.

IV.—WEATHERED DOLERITE OF ROWLEY REGIS (SOUTH STAFFORDSHIRE) COMPARED WITH THE LATERITE OF THE WESTERN GHÂTS NEAR BOMBAY.

By Dr. HUGH WARTH.

SINCE it has been proved that large areas of basaltic and other igneous rocks within or near the Tropics in India, on the Seychelles, and in Australia yield surface deposits (so-called Laterites) identical with Bauxite, it is of great importance to ascertain exactly what products of decomposition or weathering originate from corresponding rocks in a temperate climate.

My attention was drawn by Professor W. W. Watts to beds of weathered rock which overlie the Dolerite of Rowley Regis. These beds are about 20 feet in thickness and ochre-coloured. The material is so soft that it is easily crushed between the fingers, whilst its mineralogical composition and its mode of occurrence leave no doubt as to its having been formed *in sitû* from the Dolerite. I therefore decided to analyse this product. The following table contains the result:—

Column i of the table represents the composition of the original Rowley Regis rock, which was obtained as the average of three analyses, two of them by J. H. Waller[1] and a third analysis by Henry.

Column ii, the weathered product of Rowley Regis (steam dry).

Column iii, composition of Dolerite from Poonah on the Western Ghâts in the Bombay Presidency (analysed by my son F. J. Warth, M.Sc.).

Column iv, the composition of the Laterite which rests on the Dolerite at Mahabaleshwar, which is also situated on the Western Ghâts (see p. 155, Dec. IV, Vol. X, of this Magazine, April, 1903, by H. & F. J. Warth).

	ROWLEY REGIS.		WESTERN GHÂTS.	
	I.	II.	III.	IV.
SiO_2	49·3	47·0	50·4	·7
TiO_2	·4	1·8	·9	·4
P_2O_5	·2	·7	—	—
Al_2O_3	17·4	18·5	22·2	50·5
Fe_2O_3	2·7	14·6	9·9	23·4
FeO	8·3	—	3·6	—
MgO	4·7	5·2	1·5	—
CaO	8·7	1·5	8·4	—
K_2O	1·8	2·5	1·8	—
Na_2O	4·0	·3	·9	—
H_2O	2·9	7·2	·9	25·0
Total	100·4	99·3	100·5	100·0

This table shows the striking difference between the weathering of the Rowley Regis Dolerite and that of the Dolerite of Poonah, which so far may represent the whole of the Deccan Trap. Whilst the Rowley Regis Dolerite yields a product (column ii) which differs comparatively little from the original rock, this Dolerite of the Western Ghâts is altogether changed into a mixture of aluminium hydrate and ferric oxide, the most remarkable fact being the nearly perfect removal of the silica in the latter case.

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[1] For one of these two analyses see Teale's Petrology; the other being unpublished, Mr. Waller kindly permitted me to make use of it.

For a further test I levigated a sample of the Rowley Regis product very carefully by suspension in water, and I obtained about 10 per cent. of the whole as a very fine ochre-coloured powder. The composition of this fine powder steam-dried was as follows:—

$Si\,O_2$	48·3
$Ti\,O_2$	·5
$P_2\,O_5$	·8
$Al_2\,O_3$	22·9
$Fe_2\,O_3$	11·6
$Fe\,O$	tr.
$Mg\,O$	1·4
$Ca\,O$	3·8
$K_2\,O$	2·4
$Na_2\,O$	1·6
$H_2\,O$	6·8
	100·1

There is no essential difference between this fine matter and the entire weathered product, column ii of the table. Comparing the weathered product with the fresh Rowley Regis rock, we find that the process of weathering has resulted in the removal of far more basic substance than of silica. There is no tendency towards the formation of a Bauxite, but rather towards that of a clay. The relation is the same as indicated in a few other cases by Merrill, pp. 215, 216, and 223 of his work on Rock-weathering. Merrill was able to illustrate even a complete change into clay in one or two instances, and we may safely conclude that the ultimate product of the Rowley Regis rock would also be a complete clay. Anyhow, this Rowley Regis product represents altogether a different transformation from that which took place in India.

No chemical reaction is known which can account for such a complete removal of silica as has occurred in India, neither is there any explanation why such a reaction should work in India and not in England. The only hypothesis we have is the one based on Mr. T. H. Holland's novel and ingenious suggestion[1] that the silica might be rendered soluble by lowly organisms which can thrive in the uniformly warm climate of the Tropics, and not in a region of lower and varying temperature. However, there is as yet no actual proof for this hypothesis, and under the circumstances it may not be inappropriate once again to draw the attention of chemists to this remarkable phenomenon in case there might after all be a strictly chemical solution of the problem.

There is one point which requires still to be mentioned. In the above it was assumed that the surface deposits of Laterite (or Bauxite) originated *in situ* from the Dolerite. This view, however, is not shared by all observers. Some eminent geologists consider the high-level Laterite of the Western Ghâts as a derived, viz. transported, rock. If such were really the case we should only be brought face to face with another difficulty almost as great as the former. We should have to explain why and how in particular regions such vast quantities of ferric oxide and alumina were extracted from the igneous rocks, and both bases redeposited together without any admixture of other substances except mere traces of silica and titanium dioxide.

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[1] T. H. Holland on the Constitution of Laterite, GEOLOGICAL MAGAZINE, Dec. IV, Vol. X, February, 1903, pp. 59–69.

NOTICES OF MEMOIRS, ETC.

BRIEF NOTICES.

1. RECENT DISCOVERIES IN MADAGASCAR.—The first trimestrial number of this year of the *Bulletin Economique* of Madagascar and Dependencies contains a preliminary notice by Mr. Standing on the discovery of sub-fossil bones at Ampasambazimba (west of Lake Itasy).

A great number of bones, which were found embedded partly in a travertine and partly in a black "basaltic or peaty" soil, have already been received by the *Académie Malgache* of Tananarive. Besides fragmentary remains of *Hippopotamus*, Crocodiles, Chelonians, and *Æpyornis*, there are several beautifully preserved skulls and fragments of jaws and limb-bones of extinct Lemuroids, a description of which will be given in the Bulletin of the *Académie*. All the known groups of sub-fossil Lemurs are represented in the collection.

The *Megaladapis* 'group' is represented by the anterior part of a skull of *M. madagascariensis* and by several fragmentary jaws.

The remains of *Palæopropitheci* are numerous, comprising two fine skulls of a new species, together with other less complete skulls, lower jaws, and a femur.

The *Archæolemur* or *Nesopithecus* group is likewise well represented.

Of the Lemurs *sensu stricto*, two skulls deserve particular mention, the one resembling the recent *Lemur varius*, the other the extinct *L. insignis*.

Last, but not least, a fragmentary lower jaw is said to be of particular interest, as throwing light on the origin of the Aye-Aye (*Chiromys*).

2.—L. DOLLO. LES ANCÊTRES DES MOSASAURIENS. (Extr. from Bull. Scientif. de la France et de la Belgique, 1903, vol. xxxviii, pp. 1–3.)

In his memoir "Über die Varanus-artigen Lacerten Istriens" (Beitr. zur Pal. und Geol. Oesterreich-Ungarns und des Orients, 1903, vol. xv, p. 41)[1] Baron Franz Nopcsa, jun., arrives at the following conclusions:—

a. The Pythonomorpha are derived from the Aigialosauridæ.

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[1] See GEOL. MAG., 1903, pp. 119–121.

b. The Aigialosauridæ show already adaptations to aquatic life in the structure of the foot.

c. Aigialosauridæ and Varanidæ have for common (Jurassic) ancestors terrestrial Reptilia, which therefore must have had an organization very similar to that of the Varanidæ.

M. Dollo claims priority for these results by referring to pp. 259 and 251–259 of his memoir of 1892, "Nouvelle Note sur l'Ostéologie des Mosasauriens" (Bull. Soc. Belg. Géol., Paléont., et Hydr., Bruxelles, 1892, vol. vi, pp. 219–259, pls. iii, iv).

3.—L. DOLLO. LES MOSASAURIENS DE LA BELGIQUE. (Bull. Soc. Belg. Géol., Paléont., et Hydr., Bruxelles, 1904, vol. xviii, pp. 207–216, pl. vi.)

Contains some new observations on the Mosasaurians. The following remarks on the difference between *Mosasaurus* and *Plioplatecarpus* are of especial interest:—

Mosasaurus—by its strong dentition, its lateral orbits, its thin tympanic membrane, by the absence of a median basi-occipital canal, by its elongate thorax, the powerful caudal fin, and the small anterior fins—is shown to have been a *swimming Mosasaurian*, living near the surface, and enabled to capture, while swimming, the formidable creatures which formed its prey.

Plioplatecarpus—by its reduced dentition, its upward turned orbits, its calcified tympanic membrane, its median basi-occipital canal, its short thorax, its feebly developed caudal fin, and its strong anterior fins—is shown to have been a *diving Mosasaurian*, descending to more or less considerable depths, and feeding on small creatures.

4.—L. DOLLO. L'ORIGINE DES MOSASAURIENS. (Bull. Soc. Belg. Géol., Paléont., et Hydr., Bruxelles, 1904, vol. xviii, pp. 217–222.)

The author's conclusions are as follows:—

a. Boulenger was the first to point out the relationship between the Dolichosaurians and the Mosasaurians.

b. Gorgjanovic-Kramberger has given an important contribution by his description of *Aigialosaurus*, and by recognising that the Aigialosauridæ are ancestral to the Mosasaurians. He has, however, imperfectly appreciated the phylogenetic position of the Dolichosaurians.

c. The author's memoir of 1894, "Nouvelle Note sur l'Ostéologie des Mosasauriens," based on original, inedited materials, gives for the first time the real relations between the Lacertilians, the Dolichosaurians, and the Mosasaurians. For the first time also the Dolichosaurians are shown to be *genealogically* intermediate between the Lacertilians and the Mosasaurians.

d. Williston is mistaken in assuming (Journal of Geology, 1904, vol. xii, p. 45) that Boulenger and Dollo have simply adopted the views of Gorgjanovic-Kramberger.

5. THE RHÆTIC BONE-BEDS.—Mr. W. H. Wickes has published in the *Bristol Naturalist's Society's Proceedings* (x, pt. 3, 1904), an interesting and important communication on the Rhætic Bone-beds.

His summary reads as follows:—The 'Bone-bed' is not a regular or persistent bed, but a series of thin sheets (or lenticules) of varying extent, coming in at various horizons and deposited at various times. These sheets are separate and have no connection with each other, except that they are of common origin, the general structure and fossils being identical. They are chiefly caused by the Saurians and carnivorous fishes, being the remains of their victims, with the addition of coprolites, etc. The extent of each sheet was determined by the size of the shoal, and the thickness *by the time it remained at that station.* At intervals the *shoal shifted* to another station, where the process was repeated and another Bone-bed formed. Owing to deposition of sediment, each successive bed was on a higher horizon than its predecessors. These are original organic deposits *in situ, and not drifted material.* They may be summed up as submarine guano beds laid down by the floating population of the period. We must refer the reader to Mr. Wickes' paper for the details of this highly suggestive piece of work, but may mention that the pebbles in these beds are attributed to fishes, for which idea a good deal of interesting evidence is brought forward.

6. THE KIMERIDGIAN IN EAST PRUSSIA.—The thick covering of drift materials so extensively spread over the flat country of the north-east of Germany very effectually conceals the solid rocks beneath, and to ascertain their nature it is necessary to resort to boring. Near Heilsberg, in the centre of the province of East Prussia, a boring has been carried down to a depth of over 600 metres below the surface, and it resulted in the discovery of rocks of Kimeridgian age at a depth of 562 metres. Dr. P. G. Krause has undertaken the examination of the cores, and in a preliminary communication in the Zeitschrift d. deutschen geol. Gesellsch., Bd. lvi (1904), p. 56, he states that the rock is a light-gray, fine-grained sandstone with a small admixture of lime and clay. It contains *Cardioceras Volgæ*, Pavlow, very numerous, *C.* cf. *subtilicostatum*, Pavlow, *C.* n.sp., *Hoplites subundoræ*, Pav., *H.* n.sp., *Aspidoceras acanthicum*, Opp., *A.* cf. *Karpinskii*, Pav., *Exogyra virgula*, Goldf., and species of *Astarte*, *Pecten*, *Protocardium*, *Thracia*, and *Trigonia*. The Ammonite fauna shows a very close resemblance to that described by Pavlow in the *Acanthicus*-zone of the Volga district of Eastern Russia. Below 600 metres the *Cardioceras*-forms disappear, and thus the Kimeridge beds in this locality would appear to be not more than 38 m. in thickness.

7. FORAMINIFERA AND OSTRACODA FROM THE CRETACEOUS OF EAST PONDOLAND, SOUTH AFRICA.—In the Annals of the South African Museum, vol. iv, pt. 5, F. Chapman describes and figures 18 species and varieties of Foraminifera and 7 species and varieties of Ostracoda from a greenish argillaceous and sandy rock of Cretaceous age from East Pondoland, Cape Colony. The foraminifera belong to the following genera: *Haplophragmium*, *Bulimina*, *Pleurostomella*, *Nodosaria*, *Vaginulina*, *Cristellaria*, *Polymorphina*, *Globigerina*,

Truncatulina, *Pulvinulina*, and *Rotalia*. Fifteen of the 18 species are already known from the Cretaceous and Tertiary strata of this country and Germany; they are all such as would be found in quite shallow water. Of the Ostracoda, one doubtful form is of Oolitic age, 4 occur also in the Cretaceous rocks of this country, whilst 2 are described as new. The author states that the general facies of these Microzoa indicates a position intermediate between the Lower and Upper Cretaceous series.

8.—GEOLOGY OF THE TRANSVAAL, by Dr. G. A. F. MOLENGRAAFF. Translated from the French by J. H. RONALDSON, M.E. With Additions and Alterations by the Author. Royal 8vo; pp. viii, 90, 19 figures; pl. i, Geological Sketch Map; pl. ii, Geological Sections. (Edinburgh and Johannesburg, 1904.)

This memoir appeared originally in the Bull. Soc. Géol. de France, 1901, and a notice of it was given in the October Number of the GEOL. MAG. (p. 475) of the same year. The translator states that the English edition has been undertaken in the hope of bringing it within the easy reach of many busy men. The author has added a new chapter and corrected and augmented the others, and a list of the principal works of reference, brought down to the present year, is appended. This general sketch by a geologist so capable and experienced as Dr. Molengraaff may safely be commended to all who are interested in the geological structure of the Transvaal.

REVIEWS.

I.—MEMOIRS OF THE GEOLOGICAL SURVEY OF ENGLAND AND WALES. SHEETS 355 AND 356: GEOLOGY OF THE COUNTRY ROUND KINGSBRIDGE AND SALCOMBE. By W. A. E. USSHER, F.G.S.

THIS memoir is a very interesting and valuable contribution to the geology of Devonshire, although the area thus mapped and described is limited in extent. The bulk of the rocks consist of Devonian slates, etc., bordered on the south by the Metamorphic schists of the Salcombe estuary (Start and Bolt rocks). Within the area, likewise, are one or two remnants of New Red rocks, whilst the phenomena of Pleistocene and Recent deposits, including modern beaches, afford much material for study and investigation. Yet the chief interest of the memoir centres in the description of the Devonian and Metamorphic rocks, and in their relation to each other along a boundary which extends from sea to sea.

In these days of thorough research, when there would seem to be so little left for posterity to accomplish, it is some consolation to find that even within the limits of a single English county there are yet problems in its geological history which cannot be said to have been altogether solved. Amongst these questions still *sub judice*, there are few more interesting and perhaps none more obscure than the true relations of the crystalline rocks of Salcombe to the Lower Devonian rocks on their northern margin. As remarked in the preface by the Director of the Survey, "the age of the schists is left undecided by the author, though more definite views on the subject have been expressed in favour of their antiquity by Professor Bonney and Miss Raisin, and in favour of their being metamorphosed Devonian rocks by Jukes & Holl, A. Somervail, and A. R. Hunt."

It may well be supposed that there has been an extensive literature on this subject, and on p. 42 a summary of the principal works is given. Commencing with De la Beche, the father of the Geological Survey, our author observes that he approaches the subject with characteristic caution. There appears to have been a belief in some quarters that De la Beche favoured the notion that the Metamorphic schists were altered Devonian rocks. Yet his views as enunciated in his classical "Report on the Geology of Cornwall, Devon, and West Somerset," though by no means dogmatic, are strongly in favour of their entire independence of each other.

The following is the concluding passage of his chapter on the Mica Slate, Hornblende Slate, and Associated Rocks:—"Although there may be some obscurity as to the mode in which the red and grey argillaceous slates on the north come into contact with the mica and chloritic slates, the line which separates them from each other may be considered as well marked. There appears no passage from one into the other which would authorize the supposition that both were merely portions of a larger mass, one having been exposed to different conditions from the other, subsequently to their original formation, by which its first mineral character became changed. Neither does there appear any mode in which we could consider the one portion to have been buried beneath detrital accumulations and then changed, according to the hypothesis above noticed, without the adjoining mass having been subject to like conditions. If the one be an altered portion of a larger mass, of which the other constituted a part, it could scarcely have been by this process. In the absence of any contradictory evidence, it would appear fair to infer that these rocks [the mica slate, hornblende slate, etc.] belong to that class which is more ancient than the grauwacke series; and though the mica and chloritic slates of the district may be associated with rocks possessing an arenaceous aspect, even supposing they may be detrital, that they form no part of that series which adjoins them on the north." Moreover, it is important to observe that, in the explanatory column of his Index-map, the colour by which the Metamorphic series is indicated bears the legend "Chlorite Slate and Rock, Mica Slate and Gneiss."

So far, therefore, as the publications of De la Beche himself are concerned, there is nothing whatever to indicate that he favoured the hypothesis of metamorphosed Devonians, which, as we have seen, he regarded as by no means a likely solution of the problem. Yet we are confronted with this difficulty, viz., that on the old Geological Survey map the boundary between the two series is indicated, for the most part, by a faint, dotted line, and the rocks of the southern area, under the symbol *κ*, are marked in the index of colours as "Altered Devonian." This old map bears the Ordnance Survey date of 1809, but we have not seen a copy wherein the date of the geological information is engraved, neither are the names of the surveyors indicated. This is the more unfortunate because there is a marked difference in the boundary-line as shown on the old and new maps respectively, so that it would have been satisfactory to ascertain who was really responsible for having included such a considerable outcrop of undoubted Devonian rocks within the Metamorphic area in the direction of the east coast. Mr. Ussher duly notices this in his memoir, and suggests that, whilst from the Kingsbridge estuary to the west coast at Hope, "the boundary is shown with sufficient accuracy to lead one to infer that it was traced on the ground," yet that in the eastern district the boundary-line was based on conjecture. This explanation is certainly not very complimentary to the early geological surveyors.

There is more in this old inaccuracy than, at first sight, meets the eye; because if the Tinsey Head beds were included in the series of the crystalline schists, such inclusion might seem to favour the notion of progressive metamorphism, which has been a cherished hobby with some of the local geologists, but which is not, so far as the present memoir goes, favoured by Mr. Ussher. His views on this point are particularly recorded in his Report of the recent Excursion of the Geologists' Association (Proc. Geol. Assoc., vol. xvii, p. 125), where he speaks of "the entire absence of any appearance of progressive metamorphism in the Devonian rocks approaching the boundary." It would be satisfactory, therefore, to ascertain who was responsible for colouring the Metamorphic Rocks in the old Survey map as "Altered Devonian," and how far this arrangement was agreeable to De la Beche in the face of his published statements to the contrary. There was, we are well aware, a period in the history of the Geological Survey when it was the fashion to regard crystalline rocks of unknown age as the altered representatives of formations recognized in the district. This was markedly the case when the Anglesey schists were regarded as altered Cambrian. Since we are unable to assign a date to the appearance of the old Geological Survey maps of South Devon it is not easy to pursue this subject further.[1]

The two sheets of which Mr. Ussher's memoir is explanatory were published in 1898 from resurveys by the author; they mark a considerable improvement on the old Survey maps. Thus the line between the Devonians and the Crystalline Schists is for the most part clearly indicated, and the schists themselves are separated into two distinct series, viz., the mica-schists and the green or hornblende-epidote-schists, each series being shown by a different colouration. An attempt has also been made to differentiate the Devonians amongst themselves, and the Director announces that an approximate boundary will be shown, in a future edition, between the Dartmouth Slates and the overlying Meadfoot group.

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[1] We have reason to believe that the Kingsbridge area was surveyed by De la Beche. His field maps show two distinct divisions in the metamorphic area, otherwise the geological boundaries are as in the published map, *Old Series*. It should be observed that there is nothing here to connect De la Beche with the notion of metamorphosed Devonians. The responsibility for this has yet to be disclosed.

In the introduction to the memoir Mr. Ussher gives a table of the rocks in the district, which, as regards the Devonians and Metamorphics, may be abridged as follows:—

DEVONIAN OR NORTHERN AREA.

Group.	*Local Subdivisions, etc.*
MEADFOOT AND LOOE BEDS	Tinsey Head Slate Series.
	Beeson Grits.
	Torcross type.
	Ringmore type.
DARTMOUTH SLATES	Glossy, green, purple, etc., slates (constituting the lowest beds).

Some of the above series contain a certain amount of igneous rocks, the basic predominating.

METAMORPHIC OR SOUTHERN AREA.

ALTERED SEDIMENTARY SERIES ...	Mica-schists, quartz-schists, interbedded mica-schists, and quartz-schists.
ALTERED BASIC ROCKS	Green schists or hornblende-epidote-schists (presumably the higher series).

Devonian or Northern Area.

The structure of these rocks is described in the introduction. They are subject to a general east and west strike, though affected by frequent small plications, which tend to obscure the larger curves, and thus local strikes are often at variance with the general strike. In interlaminated hard grits and shales the planes of schistosity are generally bedding planes; in the argillaceous rocks they are mostly due to cleavage with which bedding accidentally coincides; gnarling is more especially noticeable in hard grit-shales or interlaminated beds: the effects of gnarling and other structural phenomena are illustrated by cuts in the text. The schistosity dips of the Devonian rocks are mostly at high angles, ranging from 60° to 90°. In three traverses taken from the Metamorphic boundary to the margin of the maps it may be noticed that the dips are either northerly or vertical in the immediate vicinity of the boundary-line, the reverse or southerly dips only occurring at some distance therefrom.

When we come to the distribution of the Devonian rocks within the area much depends upon the interpretation of an obscure stratigraphy, which has been only too fruitful of divergent opinion, though we may express a hope that the true sequence has at length been revealed to Mr. Ussher. The key of the situation seems to consist in an anticlinal of Dartmouth Slates, the lowest Devonian horizon of this district, which throws off the equivalents of the Meadfoot group on the southern wing of the anticlinal. It is with this southern wing that we are chiefly concerned, since it comprises the principal Devonian series of the district right up to the Metamorphic boundary.

The Dartmouth Slates within the area are by no means an interesting formation, traces of limestone being very rare, so that there is no reason to wonder at the lack of fossil evidence. Igneous rocks are "very occasionally" met with, some of which may be in part contemporaneous. The absence of organisms seems to be the chief distinguishing feature of these basal rocks, so that where traces of crinoids, brachiopods, or corals occur the presumption is against such strata belonging to the Dartmouth Slates.

The Meadfoot group is far more interesting, and, as its members occupy the principal portion of the Devonian area between the suggested anticline and the Metamorphic boundary, the entire series may be taken as the typical representative of the Lower Devonian in the Kingsbridge-Salcombe peninsula. The following are the divisions adopted, as we have seen, by the author, in ascending order, viz.: the Ringmore Type, the Torcross Type, the Beeson Grits, and the Tinsey Head Slate Series. Judging from the Director's preface, it would appear that when the new maps (sheets 355 and 356) were published in 1898 Mr. Ussher had not then established the fact that the Devonian rocks on the south of the Dartmouth Slates "are parts of the Meadfoot series, and correspond to the types met with in that series in the Looe, Plymouth, and Long Sands (south of Brixham) coast series" (p. 56).

Dealing briefly with the four above-named series in ascending order, we find that there is a considerable amount of brown-coloured fossiliferous material in beds of the Ringmore type, though actual limestone is seldom discernible in the inland localities. Crinoidal limestone films and lenticles, often red-stained, are met with in certain localities, and well-known Lower Devonian genera may be recognized with more or less certainty in these crushed calcareous films, though too often flattened out beyond specific recognition. On the whole, these beds must have originally included a fair amount of organic remains, and at Ringmore itself, in about two feet of glossy and variegated shales, were found flattened impressions resembling *Spirifera primæva*, *Streptorhynchus gigas*, and *Zaphrentis*; also the eye of a large trilobite, possibly *Phacops latifrons*. This seems to be about all that can be done in the way of palæontology, though doubtless the beds have been subjected to careful search for fossils.

The rocks of the Torcross type are chiefly remarkable for numerous thin bands of igneous rock, generally much decomposed, associated with the slates; in some cases these igneous rocks may be contemporaneous, though their appearance on the map is more suggestive of dykes, especially the long one at the Torcross end. Certain developments of grit, south of beds of the Torcross type, have been termed Beeson Grits, and these are shown on the map by a deeper colour. Amongst the alternative hypotheses, presently to be considered, is the possibility that these Beeson Grits constitute an anticline, so that the Torcross Slates on the north are carried over on the south of these grits. It is not easy to perceive which hypothesis most commends itself to the author, but on the supposition that the Beeson Grits merely represent an outcrop, the next series on the south, viz. the Tinsey Head Slates, must be regarded as the highest in the local Devonian sequence.

This last-named series is interesting from the fact that its southern limit is well-defined by the 'brown rocks' which border the hornblende-epidote-schists (Metamorphic group), and which limit is also more or less easily determinable, west of the Kingsbridge estuary, where the slates are in contact with the mica-schists of the Metamorphic group. It will be remembered that a considerable portion of this series to the east of the estuary was included, in the old Survey map, with the Metamorphic rocks. The author now includes with this series the "interlaminated argillaceous, calcareous, and siliceous beds" of Tinsey Head, previously grouped by him with the Beeson beds; these contain seams of crinoidal limestone, and even *Zaphrentis* has been found in the Southpool section. He also remarks that the absence of igneous rocks in these beds supplies a further argument against their correlation with those of the Torcross section.

We may observe that the so-called "Tinsey Head slate series" derives its chief interest from the fact of its being that portion of the Devonian system which is in contact, all along the line, with the Metamorphic rocks. In the days when the doctrine of progressive metamorphism appeared to find favour, the petrography of the various members of this series was the subject of much study. Even now the Director tells us (p. 25) that the mechanical structures of a much puckered rock from Tinsey Head are precisely those seen in the quartzose mica-schists. Doubtless the mica-schist section of the Metamorphic rocks represents a series of arenaceous and argillaceous deposits which may be matched by rocks occurring in the Devonian area. It would be strange if it were not so, when individual fragments of each are selected for comparison. Since, however, Mr. Ussher tells us that the boundary of the Tinsey Head slate series is well-defined, this can only result from an entire and obvious contrast in the aggregate of the rocks on either side the boundary. Doubtless he has done well to oppose the application of the doctrine of progressive metamorphism in this case, but his resources are not yet exhausted, and he has a second string to his bow, as we shall perceive in the sequel.

Metamorphic Rocks or Southern Area.

The rocks of this area, he says, present two well-marked stratigraphical groups—the green schists and the mica-schists. Of these two groups the green schists are believed to be the uppermost. "The mica-schists undoubtedly represent a series of sediments of the same general nature as those found in the Devonian area; and the green schists may unhesitatingly be regarded as an altered series of basic igneous rocks allied to the diabases in composition, and possibly consisting in part of altered tuffs." In assigning a different colour to each of these groups Mr. Ussher has effected a great improvement on the old Survey map, though we are informed that the field-maps of De la Beche also showed two divisions in the Metamorphic area. Owing to the intense folding there is a considerable amount of interplication, a feature well illustrated by cuts in the text. The cliff between the Outer and Inner Hope, east of Bolt Tail, shown as a section in the frontispiece to this memoir, serves to illustrate the relation of the mica-schists to the hornblende-epidote-schists in that particular area. The alternations of red and green in the latter series of schists would be very effective on a coloured plate.

East of the Salcombe estuary the green schists form the northern and southern fringes of the Metamorphic area, with a considerable tract of mica-schist country between them; whilst, west of the estuary, the green schists are in the middle and the mica-schists form the outsides. The general strike of the green schist zone, where the two bands coalesce to form one, would seem to be approximately north-west and south-east. This direction is oblique to the general strike of the Devonians on the north, and, taken in conjunction with the fact that the eastern half of the Metamorphic boundary consists of green schists and the western half of mica-schists, seems to point to a considerable difference of orientation in the two systems. Yet the author fails to trace any evidence of pre-Devonian disturbance.

A detailed description of the structure and petrology of the mica-schists and green schists follows, and the features of possible resemblance to their presumed analogues in the Devonian rocks are carefully pointed out. With reference to the mica-schist series, he observes that in parts of the district it would be difficult to distinguish the least altered examples of mica-schists, finely interlaminated quartz-mica-schists, and quartz-schists from examples of the corresponding Devonian sediments. Professor Bonney, he says, has drawn attention to this fact, and ascribes it to the deformation of true schistose character in the former case and to the simulation of schistose character in the latter. There are many valuable petrological notes by Mr. Teall relating both to the mica-schist and green schist series.

Lastly, the author concludes that the only volcanic development in the Devonian area comparable to the green schists is furnished by the Ashprington series. "The correlation between these groups, should the Devonian age of the Metamorphic rocks be established, is, however, less probable than the connection of the green schists with the igneous rocks of Stoke Fleming or with those in the Torcross group" (p. 50). As regards the latter suggestion, we may observe that it accords but doubtfully with the feeble and scattered development of igneous rocks in a group of slates such as that of Torcross, and seems, moreover, in direct contradiction to the stratigraphy as shown in the diagram on p. 62. The advocates of the metamorphism of the Devonian beds had better stick to the Ashprington volcanic series, the chief difficulty, of course, being to transport it within the Metamorphic area.

Nature of the Boundary between the Northern and Southern Areas.

This is perhaps the most interesting chapter in Mr. Ussher's memoir. "On the whole," he says, "the boundary of the Metamorphic area can be located with tolerable certainty owing to the comparatively unaltered condition of the slates and shales on the north side. The rapid change from one group to the other is equally evident where the green schist series is in contact with the slates, and between Malborough and Hope, where the mica-schists are in contact with them." This is a terrible blow to the old notion of progressive metamorphism, and is all the more severe because it includes in the Devonian or northern area rocks which were mapped as Metamorphic in the old Survey sheets. Professor Bonney and Miss Raisin have done good service here, and although Mr. Somervail was able to effect a slight correction in the latter author's map, it only served to shift the boundary-line somewhat to the northwards.

When we come to the consideration of local details, it must be admitted that there is a certain degree of obscurity as to the actual position and character of the boundary on the east coast (Greenstraight). This has struck more than one observer. Mr. Ussher says that "there is no break in this section, which could be taken as a fault boundary, or satisfactory junction between altered and unaltered rocks." This seeming obscurity on the east coast, which is usually the first point visited, may in part account for the controversial character of the entire subject as to the relations of the Devonians to the Metamorphics.

There seems to be better evidence further inland, for at Kellaton, he says, unaltered grey slates of the Devonian group become gradually intercalated with "yellowish-brown beds and harder rotten brown stony bands, giving place to soft peroxidated and yellow-brown materials with seams of soft reddish and dark-grey shale or schist with highly micaceous surfaces and whitish interfilming. The section appears to be a more or less rapid passage from unaltered sedimentary to decomposed volcanic material, which cannot be separated from the green schists." Since these 'brown beds' appear in the junction sections to be more or less connected with the green schists, it is only natural to suppose that they constitute a sort of decomposed and peroxidized selvage of those rocks, into which most probably portions of the Devonian slates may have been forced by pressure. They are in no sense passage beds, but simply portions of the green schists in a state of decay owing to their peculiar position. Mr. Ussher had previously stated (Proc. Geol. Assoc., vol. xvii, p. 123) "that the junction between the Devonian and altered rocks is almost invariably marked by the presence of rusty-brown decomposed rocks, generally containing hard carbonates. These rocks often intervene for a distance of several chains. The contrast between the comparatively unaltered Devonian slates and the highly altered rocks, on either side of this neutral zone, is everywhere strongly marked; nor were any evidences of progressive metamorphism detected in the Devonian rocks approaching the boundary." (See antea, p. 31.)

It is a fortunate circumstance that the numerous creeks in connection with the Kingsbridge estuary afford sections of the boundary-line, which are in some respects better than those on either coast. This remark especially applies to the Southpool Creek junction-section (west bank), described and illustrated on pp. 54 and 55. The beds representing the Devonian portion of the junction rocks at this place consist of grey slates with brown ferruginous films and a local abundance of quartz veins. These beds are intersected by several small faults, whilst the schistosity dips are mostly northerly at angles from 50° to 70°: they can be correlated with the slaty series south of Tinsey Head (east coast) and between Beacon Point and Mouthwell (west coast). The beds above described are separated by a thrust with a northerly inclination "from yellowish-brown and reddish-brown decomposed shales with tough masses, revealing hard whitish carbonate, and definite beds of chocolate-brown rock"; but the spot where the brown rocks are in normal contact with the green schists, which succeed on the south, is unfortunately obscured.

If we are right in supposing that the 'brown rocks' are, in the main, the decomposed selvage of the green schists, and if the author's section (fig. 23) and descriptions are to be relied on, we have here an admirable illustration of what may prove to be the true stratigraphical relations between the Metamorphic mass of the southern area and the Devonian rocks of the northern area, viz., the impinging of two entirely different rock systems upon each other. For such a line of contact the term 'fault' is scarcely adequate, since, owing to the crush and admixture of opposing materials, there has been established a kind of border medley to which the author has in some cases applied the term 'intermediate series.' Although this intermediate series, as we might expect, varies in character at different points, yet so far as the 'brown rocks' are concerned we must allow that the Metamorphic area has contributed the greater part of them. This supposition is, furthermore, confirmed by the facts observed in connection with the Kingsbridge estuary junction-section (east side).

We now come to an important change in the character of the boundary-line on the south side, viz., the substitution of the mica-schist series for the hornblende-epidote or green schist series. West of the Kingsbridge estuary the northern band of green schists is split up into two groups, and the northern group is continued in a westerly direction as an irregularly interplicated series of mica-schist and green schist until the former wholly prevails as the boundary rock. It is significant to note that henceforth, until the Hope section is reached, no further signs of either green rocks or decomposed brown rocks are encountered. Very little is said in the memoir about the junction phenomena along the mica-schist boundary. In one place the junction schists are said to be soft, yellow and red in part, and very micaceous. A specimen, according to Mr. Teall, is almost entirely composed of muscovite, with large opaque grains, apparently pseudomorphs after pyrite, and tourmaline as an accessory (p. 58). Further on the surface stones afford evidence of partially peroxidized mica-schists and quartz-schists.

The author considers the Hope junction-section to be the most complete in the area, and the beach reefs supply the evidence which would otherwise be lacking in the intervals between the cliff sections. Yet, for all this, the actual line of junction seems doubtful, and we are left very much in the dark after studying the diagram (fig. 25), where the author might easily have given us his view as to the actual position of the boundary. He states in the text (p. 62) that the Hope section exhibits the east coast and Kingsbridge estuary 'brown rocks' in plicated conjunction with rocks ascribed to the Devonian slates on the north side of Hope Headland and with mica-schists on the south side of it. The crux appears to be in Hope Headland itself, and the line of junction is most likely to occur in that cliff rather than at the commencement of Mouthwell beach, as shown in the old Geological Survey map and also in the new one. Undoubtedly the presence of 'brown rocks' in this area without a corresponding development of the green schists constitutes a difficulty which requires to be explained.

Mr. Ussher admits that the line taken as a junction does not correspond to an abrupt change in the character of the metamorphism, but owing to the occurrence of the 'brown rocks' north of Hope Headland, as well as in the Headland itself, he is content to place the junction in the position assigned to it in the old Geological Survey map. Professor Bonney and Miss Raisin place the line further south, the former distinguishing the rocks immediately south of Hope Headland as "true schists" from those on the north side as "never more than schistose." Thus it would appear, notwithstanding Mr. Ussher's statement that the Hope junction-section is the most complete in the area, there seems yet to be an element of doubt as to where the boundary-line should be drawn, if indeed it is possible to draw an exact line under such conditions as are presented by the juxtaposition of two opposing rock systems.

Conclusion.

The above details with regard to the boundary between the Devonian and Metamorphic rocks are undoubtedly difficult to follow by those who possess little or no acquaintance with the localities, though possibly a general idea of this peculiar apposition of the two series may be obtained. In the new map the boundary-line is drawn with precision, but no fault is indicated, and everyone is at liberty to draw his own conclusions as to the true nature of the junction. It is perfectly clear that an immense change is accomplished within a short distance on either side of the boundary, the intervening space for the length of a few chains being occupied by rocks which sometimes partake of one character and sometimes of the other. These conditions fully justify the Director, in his preface, in stating that "a striking feature of the area in question is the contrast *between the intensely* folded but comparatively unaltered Devonian rocks on the north and the Metamorphic rocks on the south."

The question then naturally arises: what are the true relations of these two different systems to each other? It is admitted that Mr. Ussher has not been able to settle the question of the age of the Metamorphic rocks by stratigraphical evidence, yet we are fully prepared to agree with the Director that "his detailed mapping of the green schists and his careful description of the line which separates the altered from the unaltered rocks will be found of value to all future workers in the district." This is perhaps as much as we can expect from an official memoir in explanation of sheets, which are a great improvement on the old Geological Survey map, where an unproved hypothesis was allowed to take the place of a simple record of facts.

It may be that the theory of metamorphosed Devonians is not altogether forgotten, for we find Mr. Teall observing (p. 45) "that whatever the age of the rocks in the Metamorphic area may be, it is practically certain that they represent a series of arenaceous and argillaceous deposits with which a considerable amount of basic igneous material was associated, and that, so far as original composition is concerned, they can be matched by rocks occurring in the Devonian area, though the igneous and sedimentary types do not occur in the same relative proportions." The petrographer thus invites the stratigraphist to perform a feat of legerdemain whereby certain Devonian rocks, such as the Ashprington volcanic series, might by some hypothetical anticlinal arrangement be transported into the requisite position. Since the application of the doctrine of progressive metamorphism finds no favour with Mr. Ussher, there is nothing left for the advocates of the metamorphism of Devonian rocks but some such explanation as is suggested, rather than put forward, in the diagram on p. 62. Here the distant Middle Devonian, with its volcanics, seems prepared to jump over the whole of the intermediate Lower Devonian and reappear in the extreme south as the schistose series of the Salcombe peninsula. It is uncertain, however, on which horse the author is prepared to win, for we remember that he has shown a preference (p. 50) for the Torcross group with its attenuated igneous bands. True, this is a much shorter leap, but the horse is only a poor one when he is landed on the other side of the ditch.

In bidding farewell to this subject we must express a hope that more sober views will ultimately prevail; and the desperate shifts to which the advocates of metamorphosed Devonians are now reduced seem to indicate that the period is not far distant when mere hypothesis must give way to a more reasonable and probable interpretation of the facts recorded in this memoir. We rejoice to see that even among the local geologists Mr. Harford Lowe (Trans. Devon Assoc., vol. xxiii, p. 523) has taken an essentially reasonable view of the relation of the South Devon schists to the Devonian slates, and some of his suggestions in that connection are well worthy the consideration of professional geologists. The extraordinary crumpling of the Devonians of the northern area, and the flattening of their fossil beds, such as they were, into mere films, are best explained on the presumption of a pressure of unusual intensity, such as might result from a squeeze between two rock masses of independent origin, viz., Dartmoor on the north and the Metamorphic schists on the south. It cannot be denied that this interpretation accords best with the stratigraphy of the region and the general structure of the Damnonian peninsula; possibly also, in the main, with the petrology of the rocks of both the northern and southern areas.

II.—CRETACEOUS CEPHALOPODA FROM THE HOKKAIDŌ. PART II: *TURRILITES, HELICOCERAS, HETEROCERAS, NIPPONITES, OLCOSTEPHANUS, DESMOCERAS, HAUERICERAS,* AND AN UNDETERMINED GENUS. By HISAKATSU YABE, University Hall, Imperial University of Tōkyō. Journal of the College of Science, Imperial University, Tōkyō, Japan, vol. xx, art. 2, pp. 45; 6 plates. 1904 (published Oct. 15, 1904).

THE first part of this work (noticed in the GEOLOGICAL MAGAZINE, September, 1903) contained a description of those Ammonites which are included in the genus *Lytoceras*, s.str., and the genera, or subgenera, *Pseudophyllites*, *Gaudryceras*, and *Tetragonites*.

In this second part the following genera are described: (1) *Turrilites*, *Helicoceras*, *Heteroceras*, and *Nipponites*; (2) *Olcostephanus*; (3) *Desmoceras* and *Hauericeras*. "The order in which the different groups are here treated is not due," says the author, "to the presence of any mutual relations existing among them, but merely for the sake of convenience and of avoiding too long a delay in the publication of the paper."

Dr. Yabe has endeavoured to make his work on these Cretaceous Ammonites from the Hokkaidō as complete as possible; he has studied not only their morphology, but the development of several of their predominating types, "for," says he, "it has now become clear that a mere morphological study of adult specimens is not sufficient for the establishment of their real affinities, and that by the study of their development only can such knowledge [be] attained."

Everyone who is acquainted with the Cretaceous Cephalopoda will agree with Dr. Yabe that in their study "one of the most difficult tasks is to define the exact limits of the different genera established on the turreted forms of Ammonites." D'Orbigny included these forms under one of the three genera *Turrilites*, *Helicoceras*, and *Heteroceras*, recognising in the first-named genus two distinct groups, *T. rotundati* and *T. angulati*. Subsequently Sharpe and Stoliczka referred the first of these groups to the genus *Helicoceras*, reserving the name *Turrilites* for the group *T. angulati*. After giving the various classifications that have been suggested for these turreted forms, concluding with that proposed by Professor Hyatt in 1900 in Eastman's translation of Zittel's Text Book of Palæontology, the author says:—"Hyatt's classification by creation of many new genera may possibly be an improvement on the previously existing ones, but it cannot be followed here, for the generic diagnoses and discussions on the taxonomy are not yet published. Therefore, the present writer is obliged to follow the old and well-known classification of D'Orbigny as modified by Sharpe and Stoliczka, though it is apparently unnatural."

The turreted forms are comparatively rare in the Hokkaidō Cretaceous rocks. Only two forms of *Turrilites* are recorded: one represented by a single small example resembling *T. Mantelli* and especially *T. Bergeri*, although specifically distinct from either; the other, also represented by only a single example, belonging to a much larger species, described as new, somewhat resembling, but less elongated than, *T. tuberculatus*. Two new forms of *Helicoceras* are described, one of which is doubtfully referred to this genus, whilst four new species and a new variety are doubtfully referred to the genus *Heteroceras*.

But of all the turreted forms described by the author the most remarkable is certainly the specimen for which the new genus *Nipponites* is proposed. Its shape is thus described: "At first the shell forms a more or less flat spiral coil wound sinistrally as in *Helicoceras*. . . . . The further growth is no longer spiral, but it consists in turning to the right and then to the left several times and thus forming many U-shaped curves which cover the first part of the shell from six directions, so that the plane of the curves roughly corresponds to the six sides of a cube." Notwithstanding the fact that the present species is represented only by a single specimen, Dr. Yabe concludes that "the mode of coiling the whorls can neither be accidental nor due to a loss of power to produce the regularly wound shell, as it is too regular to admit any such supposition. That it is a *Turrilites* or some allied genus which has modified its mode of growth on account of its advanced age is also inconceivable. Therefore, this formation of several U-shaped curves must be ascribed to the inherent power of the animal." It is for these reasons that Dr. Yabe has considered this single specimen to be worthy of a new generic name. From the form of the shell the author concludes that "the animal led neither a free swimming life nor a sessile one, but was a creeper on the sea-bottom, as is the generally accepted view of *Turrilites*."

An interesting Ammonite, which is too imperfect for its proper generic determination, possesses characters which ally it with the Indian species *Olcostephanus superstes* and *Ammonites rudra*, two species that are provisionally placed in *Olcostephanus* by Dr. Kossmat, who recognises, however, their phyletical relations to *Vascoceras* on the one hand and to *Acanthoceras* on the other.

A new species of *Olcostephanus* is described, having its nearest ally in a form described by Dr. Whiteaves from the Cretaceous of the Queen Charlotte Islands, whilst to *Hauericeras*, in addition to the genotype, *H. Gardeni*, that has been recognised in Natal, in Southern India, in Vancouver Island, in the Hokkaidō, and possibly also in Tunis and in Galicia, the author refers a new species, which is closely allied to a species from the Cretaceous of France. *Desmoceras* is represented by two forms, one of which is considered to be a new variety of the species *D. Dawsoni* which Dr. Whiteaves described from the Queen Charlotte Islands, whilst the other is regarded as new.

All the species are well illustrated on the six plates accompanying the work.

We most heartily congratulate the author upon this further most interesting contribution to our knowledge of the Cretaceous Cephalopoda from the Hokkaidō. G. C. C.

III.—SECOND REPORT OF THE GEOLOGICAL SURVEY OF NATAL AND ZULULAND. By WILLIAM ANDERSON, F.R.S.E., F.G.S., Government Geologist. 4to; pp. 171, with 11 plates and maps. (London, 1904: West, Newman & Co., 54, Hatton Garden.)

THE Report contains an account of the Survey operations for the years 1901–2, with two valuable and important contributions to the Palæontology of East Africa, one by Mr. Robert Etheridge, of Sydney, and the other by Mr. A. C. Seward, F.R.S., of Cambridge. It should be mentioned that Mr. W. Anderson is still the only member of the Survey Staff, and that its offices are limited to two small rooms in Pietermaritzburg, altogether inadequate for the proper storage of the rock specimens and fossils; and but for the fact that various collections were promptly sent for identification to palæontologists in different parts of the world, their accumulation would have made the offices practically inaccessible! On the other hand, the Natal Government do not seem to have stinted the expenditure for the publishing of the Report, which, as regards paper, print, plates of fossils, and coloured maps, has been brought out very satisfactorily, and might be commended for imitation to Surveys nearer home.

Mr. Anderson's field-work has been devoted mainly to a rough survey of the province of Zululand; in part to the coastal areas on the east, and in part to the north-western border, where he has been able to connect his work with that of Dr. Molengraaff in the Vryheid district. The whole littoral area of Zululand, in places 50 miles in width, is uniformly flat or slightly undulating, some areas swampy, others sandy, and largely covered with dense wood or scrub. The rivers by which it is traversed cut deep into the subsoils, but do not expose the rocks beneath as a rule. With the exception of calcareous sandstones and conglomerates in two or three small areas, the rocks shown on the coast are shales, marls, calcareous beds, and lignites, with soft sandy deposits of all colours. These are considered to be of Cretaceous age; the only indications of Tertiary rocks were some calcareo-arenaceous pebbles found on the coast, which contained fragmentary *Lithothamnion* and numerous Foraminifera, and an impure Diatomaceous deposit, near Lake Sibayi, which may be of Pleistocene age.

Mr. Anderson has also examined the Ecca series in the basin of the Black Umfolosi, near the north-western boundary of

Zululand, where the whole series, from the glacial (Dwyka) conglomerate upwards, is well developed. Here, as elsewhere in the country, the plant and coal-bearing beds occur in the higher part of the series, and many of the shale beds contain abundant remains of *Glossopteris* and *Phyllotheca*. With the exception of the coal-bearing series at the base of the Drakensberg, containing *Thinnfeldia* and *Pterophyllum*, belonging to the Stormberg series, and approximately of Triassic age, Mr. Anderson states that all the coal-bearing rocks of Natal and Zululand contain a *Glossopteris* flora and are of Ecca or Permo-Carboniferous age.

The Dwyka, or, as Mr. Anderson prefers to term it, Ecca Conglomerate, is widely distributed in Zululand, and occurs at all heights from the sea-level to the highest portion of the plateau; detached outliers of it are often present on the higher ridges and mountains. In a few localities, sandy beds, free from pebbles and boulders, are intercalated between the typical conglomerates. Striated rock-pavements also occur; the author mentions a fine example in the bed of the Umfolosi river, where a striated quartzite pavement, directly overlain by the glacial conglomerate, is partially denuded by the river. The author feels no doubt that this ancient conglomerate is a till or boulder-clay of terrestrial origin.

The Cretaceous fossils described by Mr. Etheridge are from a shelly limestone at Umkwelane Hill, a few miles inland from the coast. The rock is crammed with fossils, which, however, invariably break up in the attempt to free them from the hard matrix. The fossils are largely Pelecypods and Gasteropods, with a few Cephalopods belonging to *Placenticeras*, *Creniceras*, *Hamites*, and *Baculites*, and some fragmentary shark's teeth.

In all 37 species of mollusca, belonging to almost as many genera, have been determined, and their affinities carefully worked out by Mr. Etheridge, and they are admirably figured on three plates. Several species show relationships to forms from the Trichinopoly groups of India, the Chico and Tejon groups of California, the Fort Pierre and Foxhills groups of the north-west of the United States, and the Greensands of New Jersey; but no resemblance to those forming the Australian Cretaceous fauna.

Mr. A. C. Seward's report on collections of Natal fossil plants treats first on those from the Ecca coal-series of Umhlali, on the north-east coast of Natal. In these beds "*Glossopteris Browniana* is exceedingly abundant; *Noeggerathiopsis* is possibly represented, and stems doubtfully placed in the genus *Schizoneura* are fairly plentiful. No undoubted *Gangamopteris* has been recognized. On the whole the evidence would appear to support the view that the plant-beds are approximately homotaxial with the Damuda beds of India, and belong to the Beaufort Series of South Africa." The plants from the Drakensberg Range in West Natal comprise species of *Thinnfeldia* and *Pterophyllum*, together with a species of doubtful affinity, and of these Mr. Seward says that they point to an horizon considerably above that of the Umhlali plant-beds, and approximately Rhætic or Lower Jurassic.

This second Report of the Natal Geological Survey is a valuable addition to our knowledge of South African geology, and it furnishes a strong argument in favour of Mr. Anderson's appeal to the Natal authorities for further assistance to enable him to continue his arduous undertaking.

IV.—MOLLUSQUES TERTIAIRES DU PORTUGAL. Planches de Céphalopodes, Gastéropodes, et Pélécypodes laissées par F. A. PEREIRA DA COSTA; accompagnées d'une Explication sommaire et d'une Esquisse géologique par G. F. DOLLFUS, J. C. BERKELEY COTTER, et J. P. GOMES. Commission du Service géologique du Portugal. 4to; pp. 120, 1 tab. stratigr., 1 portrait, and 28 pls. (Lisbonne, 1903–1904.)

WHEN the Geological Commission of Portugal was instituted in 1857 to investigate the geology and to produce a geological map of the country two Directors were appointed, one for the geological work and the other for the palæontological studies and the care of the collections. To the latter post F. A. Pereira da Costa, then Professor of Mineralogy and Geology at the Polytechnic School of Lisbon, was appointed. In the following year all the collections of natural products from the Museum of the Academy were combined with those belonging to the Polytechnic School and constituted the National Museum of Lisbon; this was divided into two sections, mineralogy and zoology, and Pereira da Costa was made Director of the former department.

His appointment on the Geological Commission led him to decide to publish his researches on the Tertiary fossils of Portugal. Under the title *Molluscos fosseis.—Gastéropodes dos depositos terciarios de Portugal* two fascicules only were issued, dated respectively 1866 and 1867, the two comprising 252 pages of text and 28 plates. But besides these, 28 other plates of Cephalopoda, Gasteropoda, and Pelecypoda had been drawn and printed off (to the number of seven or eight hundred) for succeeding fascicules. At the conclusion of the Geological Commission in 1868 Pereira da Costa resumed his duties at the Polytechnic School, and these unpublished plates were deposited in the Library of the Mineral Section of the National Museum, which contained the specimens that Pereira da Costa had studied. But there was no text with them, and unfortunately no descriptions of the fossils that had been drawn were found amongst Pereira da Costa's papers after his death in 1889.

The plates having been handed over to the Geological Survey by the present Director of the Mineral Section of the National Museum, M. Ferreira Roquette, they are issued in the work now before us. With the assistance of M. J. C. Berkeley Cotter, of the Geological Survey, and M. J. P. Gomes, naturalist at the Museum, the explanations of the figures have been prepared by M. Gustave F. Dollfus, the French palæontologist, and are based upon the original specimens whenever possible, or upon authenticated examples of the species; whilst an original and extremely interesting sketch of the marine Miocene of Portugal has been supplied by M. J. C. Berkeley Cotter, a biographical sketch of Pereira da Costa being furnished by M. J. P. Gomes. M. J. F. Nery Delgado, the present President of the Geological Survey, contributes a Preface to the work, in which he explains that the two fascicules issued by Pereira da Costa and the 28 new plates by no means represent the whole of the marine Miocene fauna of Portugal; many discoveries having been made since the appearance of the two fascicules, whilst there are many gaps in the new series, notably among the Pelecypoda. Further, that some genera are incompletely represented, whilst others are entirely omitted. "Nevertheless," says M. Delgado, "such as they are, these twenty-eight plates are very interesting; they represent many species often imperfectly known, either hitherto badly figured or even entirely new."

A palæontological note appended to the work contains figures and a description of a new species of *Anomia*, named *A. Choffati*, after M. Paul Choffat, who is so well known for his excellent work in connection with the Geological Survey of Portugal, to which he is attached.

REPORTS AND PROCEEDINGS.

GEOLOGICAL SOCIETY OF LONDON.

I.—November 23rd, 1904.—J. E. Marr, Sc.D., F.R.S., President, in the Chair. The following communications were read:—

1. "On an Ossiferous Cavern of Pleistocene Age at Hoe Grange Quarry, Longcliffe, near Brassington (Derbyshire)." By Henry Howe Arnold-Bemrose, M.A., F.G.S., and Edwin Tulley Newton, F.R.S., V.P.G.S.

During quarrying operations in Hoe Grange limestone quarry in April, 1902, the workmen broke into a cavern. The discovery was first made known to the writers by Mr. J. Ward, of the Cardiff Museum, but the news of mammalian bones being found soon spread, and many of the remains were carried away. An arrangement to work the cave systematically was made, with the permission of the owner, Major Nicholson, and it has now been entirely worked out, the results being given in the present paper.

The quarry is situated near the top of the plateau, at about 1,100 feet above Ordnance datum. The cave is evidently a master-joint in the limestone, enlarged by water, and, besides being a swallow-hole, has served as a hyæna den. The large number of mammalian remains found includes lion, hyæna, rhinoceros, *Elephas*, and other Pleistocene forms; but besides these there were numerous bones and teeth of fallow-deer, mixed with the Pleistocene remains at all horizons in the cave. The physical conditions are such as to preclude, as the authors think, any idea of a redeposition of the bones at any date subsequent to the Pleistocene Period; and it is concluded, therefore, that the fallow-deer (*Cervus dama*) was a Pleistocene species, although hitherto supposed to be a much later introduction.

2. "The Superficial Deposits and Pre-Glacial Valleys of the Northumberland and Durham Coalfield." By David Woolacott, D.Sc., F.G.S.

Six volumes, published by the North of England Institute of Mining and Mechanical Engineers, contain a large number of borings made in the northern coalfield. A considerable proportion of these are most valuable in showing the nature and distribution of the superficial deposits. From them and from field-mapping it is possible to form a fairly accurate conception of the pre-Glacial floor of the district and its drainage, and also of the relative changes of level before, during, and after the Glacial Period. The chief superficial deposits include the following:—(1) the stony Boulder-clay; (2) the Upper Clay, including (*a*) the prismatic clay and (*b*) the leafy clay; and (3) deposits of Sand and Gravel occurring below, in, or upon the Clay. The last include raised beaches, which decline in height when traced northward and southward from Cleadon and Fulwell, with a gradient of from 3 to 6 feet per mile.

The surface deposits lie arranged in the valleys formed before the Glacial Period, and often reach a considerable depth. They fit upon and level up the Glacial inequalities of the country, and are not found above 1,000 feet. The base of the Drift is in some cases as much as 140 feet below sea-level, and in one spot the thickness bored through is 233 feet. By inserting all available borings in maps, it is possible to gain some idea of the direction and depth of the valleys. In this way the following pre-Glacial valleys have been located:—The Tyne and its tributaries, corresponding in general trend with the present Tyne, which is superimposed upon it; the 'Wash,' which joins the present course of the Wear with the Tyne, and has the Team superimposed on its northern part; the upper Wear, which received all the waters from the west of Durham county, took up several large tributaries between Bishop Auckland and Durham city, and passed through the 'Wash' into the Tyne; the Sleekburn Valley; and the Druridge Bay depression, into which the pre-Glacial Coquet probably ran. Thus in pre-Glacial times the Tyne and the Tees were the major rivers, and the other streams were tributary to them; the main changes have taken place in the lower, and not in the higher, parts of the rivers. The post-Glacial Wear has breached the Permian escarpment, and many gorge-like valleys have been cut since the uplift which produced the raised beaches. The dependence of the contour of the country on its geological structure was much more pronounced in pre-Glacial times than at present.

II.—December 7th, 1904.—J. E. Marr, Sc.D., F.R.S., President, in the Chair. The following communication was read:—

"The Chemical and Mineralogical Evidence as to the Origin of the Dolomites of Southern Tyrol." By Prof. Ernest Willington Skeats, D.Sc., F.G.S.

Recent work on modern coral-reefs has shown that these limestones contain very little, if any, insoluble residue. The study of the relative proportions of the organisms composing these reefs, and the alterations that they undergo, has further shown that corals play a subordinate part in them, and that calcareous algæ, foraminifera, and other organisms form the bulk of the rocks of the reefs. The author has applied this information in the examination of collections from the much debated area of the Dolomites of Southern Tyrol. The chemical examination of numerous specimens from the Schlern dolomites of the Schlern, the Langkofl, the Marmolata, the Sella, the St. Cassian district, the Richthofen Reef, and numerous other localities, is described, so far as relates to the proportions of lime and magnesia and of insoluble residue. These results are compared with similar analyses of limestones from lower and higher horizons. Many of the dolomites are devoid of insoluble residue, and where this is present it can generally be attributed, as in the raised reefs of Fiji, etc., to the association with contemporaneous volcanic rocks. The action of solution during the slow accumulation of deep-sea limestones, and the presence of terrigenous material in organic deposits forming near the shore, give to these limestones a much larger proportion of insoluble residue. It is therefore probable that the Schlern dolomites represent a Triassic 'coral-reef,' using the term in the modern, more extended, sense. The author proceeds, on this hypothesis, to suggest the conditions under which the dolomite may have been deposited in the different parts of the area in question. He next proceeds to the microscopical examination of specimens, with a view to the study of the organisms contained in them. While the limestones have undergone mineralogical and chemical changes similar to those of recent coral-reefs, they contain a suite of organisms comparable with those of the latter, when due allowance is made for the loss of structure due to more complete dolomitization. Forty-five per cent. of the sections yielded no trace of organic structure. In the others, calcareous algæ are the commonest fossils, echinoderm-spines and lamellibranch-shells are not uncommon, while foraminifera are occasionally found; undoubted corals are extremely rare. But reef-forming corals, gasteropoda, and some of the calcareous algæ are built of aragonite, and hence are likely to disappear under the operation of mineralogical changes; while even the more stable organisms with calcite skeletons begin to lose structure, owing to the invasion of crystals of dolomite.

With regard to the origin of the dolomite-masses, it is shown that the conditions favourable to their formation were:—(*a*) shallow water between 0 and 150 feet, and corresponding to a pressure of 1 to 5 atmospheres; (*b*) the presence of carbon-dioxide in comparative abundance causing partial solution of the limestone, and the possibility of chemical change with the magnesian salts in sea-water; (*c*) porosity of the limestones facilitating the movement of magnesian solutions; and (*d*) sufficiently slow subsidence or elevation to render the change from calcite to dolomite complete. Locally, dolomite is deposited directly from solution in confined areas or cavities in the rock; while the Raibl Dolomite, associated with gypsum, was formed by the concentration of sea-water in land-locked areas.

EDINBURGH GEOLOGICAL SOCIETY, October 19th, 1904.—Mr. B. N. Peach, LL.D., F.R.S., of H.M. Geol. Survey, President of the Society, in the chair. Opening address by the President: The Higher Crustacea of the Carboniferous Rocks of Scotland.—As early as 1835 Scouler described *Dithyrocaris*, a nebalid crustacean from the Lower Carboniferous rocks of Scotland. In 1861 Salter founded the genera *Palæocrangon* and *Anthrapalæmon*, from specimens collected by the Rev. Thomas Brown and Dr. Grossart from the Carboniferous rocks of Fife and Lanark respectively. These he thought to be macrurous decapods. Huxley, in 1862, described a specimen from Paisley, under his genus *Pygocephalus*, which he rightly placed among the schizopods.[1] From 1863 to 1882 several species of *Anthrapalæmon* were described by Salter, Etheridge, jun., and B. N. Peach, mostly from materials gathered from the Lower Carboniferous rocks, for the Geological Survey, by Jas. Bennie and A. Maconnochie. From this material Dr. Peach erected the genus *Pseudogalathea*, and showed that the American genus *Palæocaris* of Meek and Worthern occurred in Scottish rocks. With the exception of the last genus these crustacea were held to be macrurous decapods.

On the publication of the Report on the Challenger Schizopods by G. O. Sars, Dr. Peach had reason to change his opinion, and after studying a great deal of new material gathered for the Geological Survey by A. Maconnochie, and from material from Ardross in Fife obtained by William Anderson, he has been able to demonstrate that *Palæocrangon* belongs to the family *Euphausiidæ* and *Anthrapalæmon* and *Pygocephalus* to the *Lophogastridæ*, while *Palæocaris* has been found to belong to the family *Anaspidæ* made to hold the recent *Anaspides* of G. M. Thompson. These points were shown to the meeting by means of lantern slides photographed either direct from the fossils or from drawings made by Dr. Peach. Dr. Peach also showed photographs of schizopods which had assumed squillid characters. He was of opinion that in Carboniferous times the schizopods were the highest forms of crustacea then extant, and that the decapods had not then been evolved.

From the nature of the sediments in which their remains are embedded, and from the other fossils found associated with them, these old schizopods must have lived in shallow water near shore. At present the *Euphausiidæ* are for the most part pelagic, the *Lophogastridæ* inhabit the bed of the deep sea, while *Anaspides* has only yet been found in a fresh-water pool in the mountains of Tasmania. The decapods have now usurped the present shores and the shallow seas.

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[1] See also paper by Dr. H. Woodward in Trans. Glasgow Geol. Soc., 1866, vol. ii, pp. 234–247, pl. iii, giving figures and descriptions of *Pygocephalus Cooperi*, *P. Huxleyi*, *Anthrapalæmon Grossartii*, etc.—EDIT. GEOL. MAG.

Dr. Peach further showed that all the above families existed in the earliest Carboniferous times, and that they must have branched off from a nebalid stem at a much earlier geological date.

MINERALOGICAL SOCIETY OF LONDON, November 15th.

Professor H. A. Miers, F.R.S., President, in the chair. Dr. J. W. Evans described two new forms of quartz-wedge, by means of which approximate quantitative estimations can be readily made of the double refraction of minerals in small grains or in rock-sections. Mr. J. Currie contributed a note on some new localities in Scotland and the Faroes of gyrolite and tobermorite, and Mr. C. R. Lindsey one on the occurrence of microscopic crystals of brookite with anatase in the Cleveland ironstone. Mr. R. H. Solly exhibited and described various minerals from the Lengenbach quarry, Binnenthal. Three of these were new, viz. marrite and bowmanite, of which the chemical composition has not yet been determined, and lengenbachite, which has been shown by Dr. Hutchinson to be a sulpharsenite of lead containing some copper and antimony, and having a specific gravity of 5·8. Marrite occurs in small lead-grey crystals resembling modified cubes, and lengenbachite in thin lead-grey blade-shaped crystals, some as long as 40 mm., showing a highly perfect cleavage. Marrite crystallises in the oblique system with $a : b : c = 0{\cdot}57634 : 1 : 0{\cdot}47389$, and $\beta = 88^\circ 45'$, while lengenbachite is probably anorthic. Bowmanite occurs in small honey-yellow rhombohedral crystals with $111 : 100 = 53^\circ 50'$. It has a highly perfect cleavage parallel to 100, and a specific gravity of about 3·2. The author also described twinned crystals of seligmannite dispersed over large crystals of dufrenoysite and baumhauerite, and curious highly modified crystals of blende showing a thin metallic lead-grey coating. Mr. H. L. Bowman described crystals of a mineral from Cornwall which had been sent to him for determination by Mr. F. H. Butler. They were found to be bertrandite, a mineral new to the British Isles. Mr. G. F. Herbert Smith exhibited a slightly modified form of the hand refractometer which he had previously described. Mr. H. Hill contributed notes on some applications of the gnomonic projection to crystallography, and on the construction of crystallographic projections.

MANCHESTER UNIVERSITY GEOLOGISTS' ASSOCIATION.

A meeting was held in the Geological Lecture Theatre of the Owens College, Manchester, on December 8th, at which it was resolved to establish a Manchester University Geologists' Association. The object of the Association is to afford a centre of social reunion for the discussion of geological subjects. Past and present students of the University are eligible for membership, also others interested in geology who may be recommended by the Committee.

Professor Boyd-Dawkins was elected President; Mr. B. Hobson and Mr. Winstanley, Vice-Presidents; Mr. W. J. Hall, Secretary; and Mr. O. B. Leigh, Treasurer; and in addition Mr. C. R. Lindsey, Mr. H. B. Hewlett, and Mr. G. Hickling were appointed members of the Committee.

The meetings are to take place monthly, during the University Session, at the Owens College, and excursions will be arranged to places of geological interest in the Spring and Summer.

CORRESPONDENCE.

THE LOWER CULM OF NORTH DEVON.

Sir,—In the Geological Magazine, November, 1904, pp. 530–32, appears a Note by Dr. Arthur Vaughan on the above beds.

Never having worked in the Carboniferous Limestone areas of Chepstow, etc., or the foreign equivalents referred to, I am unable to express an opinion on the conclusions arrived at by Dr. Vaughan. But I must take exception to the observations contained in the last paragraph of p. 531 commencing "I further deduce," etc.

The beds from which the fossils north-west of South Molton were collected *are* the *Posidonomya* beds, and these fossils occur in calcareous bands intercalated with the *Posidonomya* shales and limestones. I cannot, therefore, accept the statement that these beds are at a "somewhat lower level" than those of Codden Hill. On the contrary, I believe them to be the continuation of the Venn and Swimbridge beds and therefore above the highest zone of Codden Hill. Dr. Vaughan admits that he is not personally acquainted with the Codden Hill district. May I be allowed to suggest that he makes himself so, when I think he will see that an area such as this is not quite so easily 'zoned.' Or, at least, that the question can hardly be decided on the evidence of a part of the fauna only. It is a mistake, I think, to attempt such a thing without taking into consideration the *whole* of the fossil evidence, stratigraphy, and lithological character of the rocks.

The locality from which the fossils referred to come, should be described as south of *North* Aller not South Aller. This was an error on the labels of my fossils and no fault of Dr. Vaughan's.

J. G. Hamling.

The Close, Barnstaple,
November 9th, 1904.

CEPHALOPODA FROM NORTH-WEST FRONTIER OF INDIA.

Sir,—In my "Note on two Cephalopods obtained by Lieut.-Col. Skinner, R.A.M.C., from the Valley of the Tochi River on the north-west frontier of India," which appeared in the Geological Magazine for October last (pp. 490–493), the locality of the Ammonoid (*Crioceras*?), as given in the explanation of the figures, differs somewhat from my statement in the text. This fossil should have been described as "derived: found in the Alveolina limestone at Mirám Shah, east of Dandi plain." G. C. Crick.

British Museum (Natural History).
December 13th, 1904.

THE MEANING OF THE WORD 'DEUTOZOIC.'

Sir,—May I request some better Greek scholar than myself to tell me the meaning of the word 'Deutozoic,' which appears in the title of an article in your Magazine for last December (p. 591). The second half leads me to suppose it has been formed from that language, but I have searched my Lexicon (a large one) in vain for any such word as *deutos*. Our old acquaintance *duō*, which survives in several languages—two in English—has a comparative *deuteros* (second) and occasionally a superlative *deutatos* (the last), but obviously the former would make 'Deuterozoic.' I find indeed a word *deute* ('hither' or 'come on!'), but that would make nonsense. Perhaps, however, the word has been fabricated or quoted at this time to show that 'compulsory Greek' at Oxford and Cambridge is no real protection to the language. T. G. Bonney.

OBITUARY.

GEORGE VIVIAN POORE, M.D., F.R.C.P.

Born September 23, 1843. Died November 23, 1904.

We regret to record the death of Dr. G. V. Poore (formerly medical attendant to H.R.H. the Duke of Edinburgh on board the 'Galatea,' and afterwards to H.R.H. Prince Leopold, Duke of Albany), Consulting Physician to University College Hospital, and one of the leading authorities on Sanitary Science. In his "London, Ancient and Modern" (Cassell & Co., 1889), the author treats of the condition of the city and its suburbs and the health of its inhabitants in the past 300 years, and it is full of interesting historical matter and excellent observations on the form and nature of the ground, of springs and wells, and sanitation. In his latest published work entitled "The Earth in relation to the preservation and destruction of Contagia" (1902), he dealt with many matters in which medical science and geology are intimately concerned, such as soils and water-supply, drainage, military camps, etc. In this, as in previously published works, he condemned those "systems of sewerage which carried away from the soil matters capable of enriching it," and he justified his conclusions by reference to personal experiments on his own property at Andover.

THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE V. VOL. II.

No. II.—FEBRUARY, 1905.

ORIGINAL ARTICLES.

I.—NOTE ON THE AGE AND LOCALITY OF THE *ESTHERIELLA*-SHALES FROM THE MALAY PENINSULA.

By R. BULLEN NEWTON, F.G.S.

MR. JOHN B. SCRIVENOR, B.A., F.G.S., Geologist to the Federated Malay States, has forwarded to me for determination several pieces of a dark-greyish argillaceous shale, largely charged with particles of mica and valve-impressions of a small phyllopodous Crustacean, which he has discovered in the Native States of the Malay Peninsula.

In his letter Mr. Scrivenor remarks: "The fossils that I send were found by myself on the surfaces of a series of shales and sandstones, practically vertical and striking N.N.E.-S.S.W., at Pukus Semanggol, Larut, Perak. This series is of enormous extent; I have traced it over 180 miles north and south along the railway. So far no fossils whatever have been found in them, that I know of, in the Western States."

Before attempting to describe these fossils myself, I thought it desirable to submit them to Professor T. Rupert Jones, F.R.S., our principal authority on the fossil Phyllopoda; and he, fortunately for science, has taken so keen an interest in the specimens that he has carefully diagnosed their characters in a systematic description, and so made a valuable contribution to the palæontology of this little-known area of the Oriental region. Professor Rupert Jones' examination enables him to state that the shales contain only one form of this curious group of Crustaceans, which he refers to a new variety of an already described species from the Triassic rocks of Sicily known as *Estheria radiata* of Salinas. As the adult specimens exhibit radial as well as concentric sculpture, Professor Jones places this species under the generic name of *Estheriella*. From a stratigraphical point of view this determination is most satisfactory, as it furnishes additional evidence of the presence of the Trias formation in the Malay Peninsula, marine Triassic shells having already been reported by me from that country (Proc. Malacol. Soc. London, 1900, vol. iv, p. 130, pl. xii). It is interesting to note that the genus *Estheriella*, originally established by Weiss for species peculiar to the Bunter Sandstone of Dürrenberg, in Saxony, so far as can be ascertained, is only known to have existed in Triassic times.

II.—Note on a Triassic *Estheriella* from the Malay Peninsula.

By Professor T. Rupert Jones, F.R.S., F.G.S.

(PLATE II.)

Introduction.

NUMEROUS specimens (having the general aspect of *Estheria*) lie on the bed-planes of a bluish, slightly micaceous, non-calcareous shale from the "Shale and Sandstone Series" of the Federated Malay States. The valves lie flatwise in the strata, either singly or in still connected pairs; and are not so much compressed but that they show the concavity of the insides, and the convexity and special features of the outsides. There are many examples of valves in different stages of growth, but a striking similarity of character indicates that all belong to one species. The shell itself is absent, but hollow moulds of one valve and solid casts of the other supply material for defining its character. No other organisms have been recognized in the shale.

Description of the Species.

The valves (see Pl. II. Figs. 1–3) are broadly subovate, nearly semicircular, short, and broad or oval-oblong with rounded ends. The anterior extremity has the bolder curvature. The dorsal border is nearly straight; ventral border boldly curved. The umbo is towards the anterior end of the dorsal border, at about one-third of the length of the valve. Behind the umbo the border gently slopes to the postero-dorsal angle, and has a distinct but narrow marginal fold. The valve is of the same shape as fig. 19 in pl. iii, "Monograph of Fossil *Estheriæ*," Pal. Soc., 1862, p. 103, but with a more definite postero-dorsal angle; the short form, var. *subquadrata*, of the Wealden *Estheria elliptica* (4½ mm. long).

Many concentric parallel ribs or wrinkles, such as are observable in known *Estheriæ*, are shown by these Malayan specimens, both on the casts of the outsides and in those of the insides of the valves. In some respects, however, these concentrics of the Malayan species differ from those of almost all other Estherians, namely, (1) in being less ridge-like, broader, and more convex individually; (2) in having numerous small, subsidiary, parallel, raised lines, intercalated on their surfaces and in their interspaces; and (3) by being crossed with a radial ornament. The main concentrics or wrinkles are about fifteen in number, and are frequently seen to be pushed up into ridges near the umbo, as in specimen 'A,' Pl. II, Fig. 2, corresponding in its raised concentrics to the furrows in specimen 'B,' Pl. II, Fig. 1. At the umbo they are squeezed together, and indeed crushed down; but they are broader and rounded elsewhere. Throughout they are marked with the supplementary riblets (5 or 6) both on the regular costæ and others between them where there is interstitial space enough.

The Malayan specimens are characterized by having twenty-four and more delicate, close-set, parallel, linear furrows radiating from the umbo to the ventral edge of the valve. In some cases they are more distinct on the anterior than on the posterior moiety of the valve, and sometimes more so on either than in the middle. In some valves, however, the radial lines are persistent throughout the ventral region, as, for instance, in the specimens shown by Figs. 2–4. A noticeable feature due to existence of these very thin radial sulci is that the surface of the adult shell has the aspect of having been squeezed transversely, and thus modified by the intervals between these slight (but sufficiently deep) furrows being puckered up into small, regular, parallel, radial ridges, crossed by the frequent successional edges of growth in the shell, and by the interstices of the concentric costæ. (See Fig. 4.)

Very fine delicate parallel lines are also recognizable on the radial ridges (see Fig. 4). The radial lines and ridges supply the generic characters of *Estheriella*, Weiss (Zeitsch. deutsch. Geol. Ges., vol. xxvi, 1875, p. 711, note; and R. Jones, Geol. Mag., 1891, p. 53).

Comparison of the Malayan with some Sicilian Species.

Some closely allied fossil species (presumably of Triassic age) have been figured as *Estheriæ* by Professors G. G. Gemmellaro[1] and E. Salinas,[2] to which these Malayan specimens have much resemblance. Professor Salinas gives full descriptions of the species he has figured.

Comparing the best of our specimens (Pl. II, Figs. 1–3) with Salinas' *Estheria radiata*, op. cit., pl. i, fig. 6, we see that they are rather larger, that the dorsal border is more strongly modified by the umbo, and has its two moieties more unequal than in Salinas' fig. 6; but it is nearly straight throughout, although slightly modified by the somewhat protruding umbo. Specimens 'A' and 'B' differ from *Estheria Ciofaloi*, Salinas, op. cit., pl. i, figs. 1–5 (especially figs. 1–3), in its shorter dorsal edge and less oblong outline. The subtrigonal aspect of figs. 2 and 3 may be due to a partial imbedment, such as occurs with numerous shells of a similar shape.

In the Malayan specimens we also find that the concentrics are broader, each bearing five or six costulæ; and that the radials are more numerous, thicker, and stronger; also that the Sicilian figures do not show any small intercalated concentrics, either on the broad ribs or in the interspaces.

Some of the above-mentioned differences in form are not of much importance; but on account of the numerous, thin, intercalated concentrics, and the radial lines occurring all over the ventral region (Pl. II, Figs. 1–4), I prefer to regard this form as somewhat different from Salinas' *Estheria radiata*, and to name it *Estheriella radiata* (Salinas), var. *multilineata*, nov.

An analogous structural aspect of the surface in a valve is shown by figs. 5–6 (particularly fig. 6*b*) in plate v of vol. ix of the Trans.

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[1] G. G. Gemmellaro, "Sul Trias della regione occidentale della Sicilia": Atti Accad. Lincei, ser. III, vol. xii (1882), Rome (Memorie), pp. 451–473; pp. 455–456, *Estheria Ciofaloi*, Gemm. (not described), pl. v, fig. 13.

[2] Emmanuele Salinas: "Sulle Esterie del Trias di Sicilia," small 4to, Palermo (Museo Geol. Min. R. Univ. Palermo), 1897, pp. 1–12, pl. i.

Geol. Soc. Glasgow, 1890 (or 1891), described as that of the Carboniferous *Estheria tegulata*, Jones, at p. 84. In *E. tessellata*, an allied form (ibid., p. 82, pl. v, figs. 2–4), a similar arrangement is also shown of a concentric being crossed by a radial system o structural lines.

The Figs. 3*d*–*g*, Pl. XI, Geol. Mag., 1897, pp. 289–293, might b regarded of special interest as showing how much the interstitial bar-ornament may be sometimes developed into superficial radials but the intermediate stages are wanting. In *Estheriella* the radial certainly have the appearance of having been due to pressure a nearly a right angle to the vertical height of the valve, giving th sharp radials in Figs. 11 and 13 of Pl. II, Geol. Mag., 1891. Wha may perhaps be looked upon as obscure traces of *radials* (regarde at the time of description as probably the remains of pressur wrinkles) are visible in the figure of *Estheria Greyi*, Geol. Mag., 1878, Pl. III, Fig. 1. Better and more numerous specimens ar wanted for further detailed examination.

EXPLANATION OF PLATE II.

Fig. 1.—Malayan specimen 'B.' *Estheriella radiata* (Salinas), var. *multilineata*, nov. A pair of valves, lying open, with the outer surface exposed. Magnified 3 diam.

" 2.—Malayan specimen 'A.' The same species. A pair of valves, lying open and exposing the insides. Magnified 3 diam.

" 3.—Malayan specimen '10.' The same species. Dextral valve. Magnified $\frac{4}{3}$ diam.

" 4.—Malayan specimen '10.' The same species. Part of the surface of Fig. 3. Magnified 8 diam.

III.—Notes on some Rocks from Ararat.

By Professor T. G. Bonney, D.Sc., LL.D., F.R.S.

During a journey through Russian Armenia in 1893 Mr. H. F. B. Lynch ascended Ararat and collected a number of small specimens from that mountain and other parts of the country These, after his return, he placed in my hands, requesting me t examine them. At that time he intended to include my report i a book then in preparation, which was completed after a secon journey (through the Turkish provinces) in 1898.[1] On thi occasion he was accompanied by Mr. Felix Oswald, B.Sc., wh studied the geology of the country and collected numerou specimens. Mr. Lynch accordingly decided to omit from his wor all geological details, and leave these to be dealt with separately b Mr. Oswald. But some time must still elapse, owing to th pressure of official duties, before he will have completed the work and as they did not, on the second journey, go near Ararat, I hav decided, since the mountain has so much historic interest, to publis my notes, though a little has already appeared on this subject Herr H. Abich, to whose unwearied labours we are so greatl

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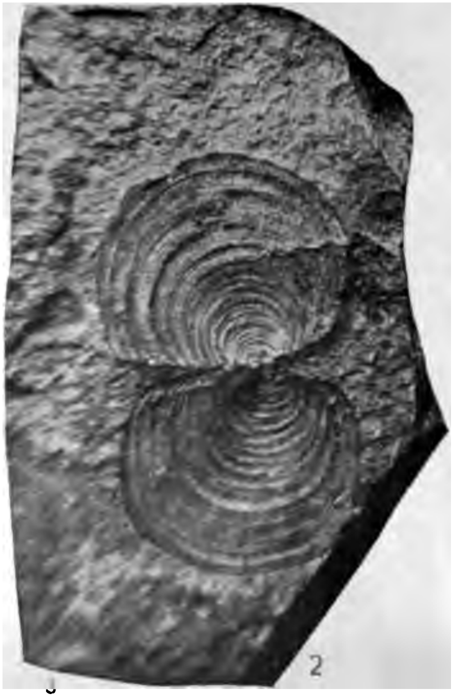
[1] "Armenia: Travels and Studies." 2 vols. Longmans, 1901. The ascent o Ararat is described in chs. xi–xiii (vol. i).



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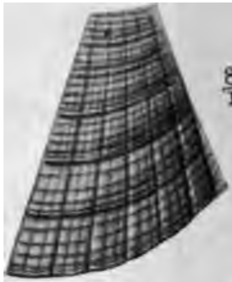

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$\frac{8}{1}$

3

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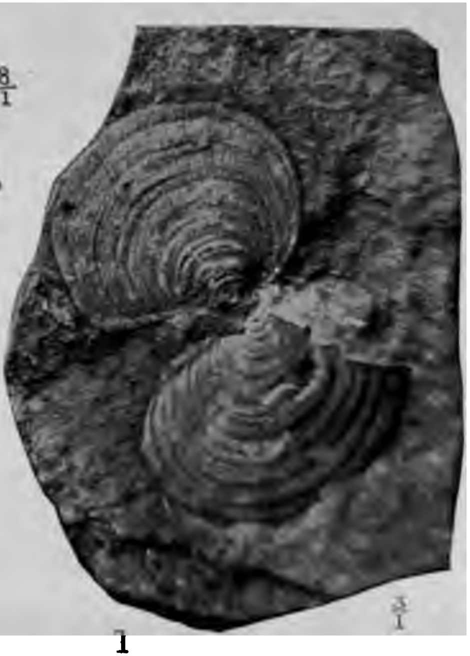

1

$\frac{3}{1}$

Highley phot. et del.

J. J. Waddington, Ltd.

indebted for information about the geology of Asia Minor, ascended Ararat on July 29, 1845,[1] and Dr. F. Becke[2] has described the microscopic structure of three specimens which he brought down. One is from the summit, another from a parasitic cone, Takjaltu, on the south-east slope, and a third from the same slope of Little Ararat. Mr. Lynch's collection, as will be seen, is a much larger one, so that it gives a more complete idea of the materials of the mountain.

The volcanic mass of Ararat, a natural monument to mark the place where three empires meet, rises at one end of the Aghri Dagh range from a rudely elliptical base measuring about 28 miles from N.W. to S.E. by 23 miles in the transverse direction. The mountain viewed from the north, where it is seen towering up to some 14,000 feet above the Araxes valley, shows a long ridge, its eastern end crowned by the fairly steep cone of Little Ararat (12,840 feet), from which it descends to about 9,000 feet, and then rises, at first gently, afterwards more sharply, to the snowy pyramid of Great Ararat (16,916 feet).[3] On its northern side a chasm or glen runs up towards the summit into the heart of the mountain. This also was visited by Mr. Lynch, who informs us that in 1840 it was to some extent modified by an earthquake.

Great Ararat.

In his ascent of Ararat he encamped first at a height of about 7,500 feet in an upland valley on the northern side of the depression (about 8,800 feet) between Little and Great Ararat, and for the second night on the south-eastern side of the latter, at an elevation of 12,194 feet. A specimen marked Great Ararat Camp (A) is a dark-grey rock containing numerous whitish felspar crystals (up to about 0·1 inch in diameter) and some minute vesicles. Microscopic examination shows a base consisting of a light-brown glass crowded with minute prismatic microliths and speckled with opacite. In this ground-mass are scattered grains of hematite or magnetite and crystals of plagioclase felspar.[4] The latter frequently contain numerous glass enclosures with vacuoles, which not seldom are crowded in an outer zone of the crystals. Pyroxene also occurs, and although the grains of it have a general resemblance, there is probably more than one species present. Some exhibit slight pleochroism and straight extinction, indicating a mineral akin to amblystegite, while in others the extinction angle varies, being once or twice large enough for augite.

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[1] For early ascents of Ararat, see Alpine Journal, vol. viii, p. 213.

[2] H. Abich: "Geologische Forschungen in den kaukasischen Ländern," iii, 102. A general description of the chief varieties is given by Dr. Parrot, who made the first ascent in 1829 ("Journey to Ararat," p. 198, N.D.).

[3] This is the height given by Mr. Lynch; other authorities make it 17,100 feet. The snow-line in Summer is about 13,500 feet.

[4] I prefer to leave this indefinite name in all these rock-specimens. Many of the crystals are not fitted for measurement by reason of enclosures, etc. Others give indefinite results, but in most of the specimens I have identified labradorite, and more than one species is present, the microliths agreeing better with oligoclase. I have thought it needless to note the variations in size. The largest (in B, *b*, 1) is about ·08 inch long, but they commonly range from about ·06 inch downwards, the pyroxenes running a little smaller.

"Below the summit of Great Ararat (B)." Twenty-eight rock fragments, some of them very small, were collected just below the summit[1] of Great Ararat, at about 16,700 feet. They vary much in colour and aspect, but probably include only three or four varieties.

One group (B, *a*) appears to be represented in its freshest condition by a dark-grey rock resembling that already described, and the microscope shows no great difference. The glassy base is a little more ferrite-stained and has fewer distinct transparent microliths; the plagioclase felspars have fewer and smaller glass enclosures; the pyroxenes are similar, one or two being certainly augite.

A second group (B, *b*, 2) is represented in its freshest state by a slightly darker, more porous, more porphyritic rock. A slice of it shows a larger amount of glass than the others, this being of a rich brown colour with granules of opacite and a fair number of transparent microliths. In it we find grains of iron-oxide (hematite in part); plagioclase felspars, generally idiomorphic, occasionally with rather abundant glass enclosures in the larger specimens (probably from partial melting), and a light-brownish pyroxene, some crystals of it certainly augite, perhaps one or two amblystegite.

Three specimens (B, *b*, 1) of a blackish glassy material studded with small crystals of white felspar. The specific gravity of one specimen is 2·483.[2] A slice cut from one of the specimens shows a glass which exhibits a fluxional structure and is present in larger amount than in any of the other rocks. It is generally brown, but with almost colourless streaks, is studded with microliths, both minute belonites and small prisms apparently of felspar, and is slightly spotted with granules of iron-oxide. In this base are crystals, sharp-edged, broken, or rounded, of plagioclase felspar, magnetite, or hematite, hornblende and amblystegite. Glass enclosures in the felspar are small in size and variable in amount, in several cases developed mostly in the exterior zone. The rock is a pitchstone (andesite).

A number of light-coloured fragments (B, 6) varying from yellowish-grey to almost white, the differences probably being due to the amount of decomposition. A specimen sliced shows the rock to be less well preserved than the others, but its differences are only varietal. It also contains amblystegite.

The description of Herr Abich's specimen, said to come from the summit of Great Ararat (on which no rock was exposed when Mr. Lynch reached it), agrees so closely with that given above under B, *b*, 1, that I have little doubt the rocks are substantially identical. His specimen contains a rhombic pyroxene which Dr. Becke names bronzite, but which I think would now be regarded as amblystegite, and a green non-pleochroic augite instead of the fairly pleochroic (brownish-green) hornblende.

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[1] The highest rock visible at the time of Mr. Lynch's visit.

[2] Determined by Walker's balance.

The specimen from the Takjaltu, a parasitic cone on the south-east slope of Ararat, must have come from the main pyramid not very far from Mr. Lynch's line of ascent. It is "a pale grey compact porphyritic rock, with plagioclastic felspar and a little sanidine, glass enclosures being frequent, sometimes forming a kind of network. A pale green, almost colourless augite is rather rare, with remnants of a strongly pleochroic hornblende (*a* pale yellow, *b* red-brown, *c* brown-red) and a pale green, almost colourless bronzite more abundant than either."[1]

A specimen from the south-east side of Little Ararat is a porous bronzite-augite andesite, in which Dr. Becke recognises oligoclase or andesine, rich in glass inclusions, magnetite, a green augite, and 'bronzite' in long thin prisms up to ·06 inch.

Chasm of Arguri (Great Ararat).

Three are labelled as "typical stones." Two of these (C) are yellowish-brown fragments, obviously rotten lava. The third (D) is a compact darkish-grey rock, speckled with lightish-grey. A slice of this exhibits only varietal differences from some of those already described; the base is nearly that of the specimen A. There are crystals of felspar and of pyroxene as before, though the former are not quite so large as usual.

Of the other rocks (E) from Arguri, three appear to be consolidated andesitic ash or fine breccia; three are lavas in a very decomposed condition; one is a slightly porous reddish rock, with small crystals of glassy felspar, probably allied to some of the varieties already described; and another is a similar rock of a more glassy aspect and deeper red colour, both the felspars and the glass intervals being slightly larger. A slice from the last shows the actual glass to be fairly clear, but it is studded with very minute, slightly brown microliths, and contains a large number of rodlets of iron-oxide. It exhibits a fluxional structure. The porphyritic minerals call for no special remark except that the rock is rather deficient in pyroxenic constituents.

Little Ararat.

Two rocks[2] (F), one evidently a grey andesite similar to those already described, the other pinker in tint, probably much the same kind but rather decomposed; it may be this rock which gives the peak its dominant violet hue. Microscopic examination shows the former to be a pyroxene-andesite with only insignificant varietal differences from the grey rocks already described. Pyroxene is not very abundant, but among it is augite, perhaps also amblystegite.

A third specimen (G) is a rock of generally similar structure, but of more brick-red colour. (It is stated to give a pinker tinge to some parts of the peak.) This exhibits some slight differences under the microscope. Its base is a sienna-brown glass, containing numerous felspar microliths, with some grains of hematite, perhaps also of pyroxene. In this are plagioclase felspars, much as usual, and some pyroxene crystals, most of which appear to be augite.

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[1] A condensed translation of the original description.

[2] Said to be typical of the dominant rock of the peak.

Other Rocks from Little Ararat.

Three specimens (H). One is a slightly porous, dark rock, with small crystals of lighter-coloured felspar; another a similar rock, but a little more porous, and the felspar slightly less conspicuous; both these weather an Indian-red colour, and the latter is slightly streaked with that tint. A third rock is a piece of vesicular scoria of a purplish-brown colour, weathering red. The microscope shows the base of the first specimen to be a rather light-brown glass (containing numerous acicular microliths and grains of opacite) in which are scattered many felspar crystals of various sizes, up to about 0·11 inch, the larger not unfrequently broken and sometimes full of glass enclosures. There is also some augite, distinct amblystegite, and iron-oxide. The larger minerals are pretty clearly of a distinctly earlier date than the final consolidation of the rock. The second specimen shows only varietal differences from the other one; the glass is rather browner, the felspar crystals do not run quite so large, and augite distinctly predominates over amblystegite. The arrangement of the glass enclosures in some of the felspars suggests that they have been produced by a local melting down rather than by inclusions of magma. The ground of the red streaks under the microscope is a richer red, more like that of G. These two rocks most resemble B, *b*, 2.

General Remarks.

So far as we can infer from these specimens, the rocks of Ararat, considering its size, exhibit surprisingly slight differences. They are augite-andesites, varying slightly in the nature of the glassy base, the size of the felspars, the occasional presence of a hornblende, and the amount of amblystegite, which mineral, however, probably is rarely quite absent. The larger felspars are sometimes corroded or broken, and not unfrequently an outer zone may be distinguished, by either containing more enclosures, or being more free from them, or extinguishing at a slightly different angle. The enclosures apparently are of five types — (*a*) small separate microliths or mineral granules, in some cases possibly a pyroxene, (*b*) very minute belonites, associated in clouds, (*c*) minute dust, (*d*) brownish glass, (*e*) cavities. Where one or more is conspicuous this is noticed above, and I am disposed to regard the glass enclosures as more often results of partial and local melting in a crystal owing to irregularities of chemical composition than to enclosures of the original magma.

Aghri Dagh.

This name is applied to the range of which Ararat forms the eastern bastion, and sometimes even to that mountain. It is nearly 100 miles in extent, its peaks rising in one case to more than

11,000 feet above sea-level, and its passes 7,000 to 8,500 feet.[1] It was crossed by a pass south of Kars (slightly to the west), from some part of which these specimens must have come (see vol. i, ch. xx). The rocks are said to be granite, diabase, etc.

A fairly coarse gneissoid rock (L, 2) is composed of quartz, pale pinkish buff felspar, and a green mineral. Under the microscope it is seen to consist of quartz, felspar (plagioclase apparently predominating), and a green chlorite. The rock, on examination with crossed nicols, seems to have been much modified by pressure, although now it is completely cemented. The larger grains of quartz have a fragmental aspect, and much of the mineral proves to be a mosaic of small grains, with a slightly streaky arrangement. The felspar has the same aspect, and some of the crystals are breaking up into a mosaic of small granular felspars with a few flakes of white mica, the latter occurring elsewhere in the slide, though sparingly. The green mineral is apparently a chlorite, and there are also two small garnets and one or two zircons. From its general aspect I should consider the rock to be very old, as considerable mineral changes have occurred since it was acted upon by pressure.

Two specimens of a compact dull reddish-purple rock. It is found, under the microscope, to consist of long microlithic crystals of plagioclase felspar imbedded in a ferrite-stained base, and is not in a good state of preservation. Probably it comes near to the basalts, and formerly would have been called a melaphyre. The specific gravity is 2·709. A veined specimen appears, from the label, to be connected with this, though the rock itself is greener in colour, more like the next in order. The vein chiefly consists of calcite and epidote, with some iron staining.

A compact dull green rock (K), slightly veined with calcite, which forms jagged ridges, between Kagizman and Karakilisa, running like walls from north to south. Under the microscope it is found chiefly to consist of two minerals, the most abundant, green, probably a hornblende; the other, clear and colourless, most likely replacing a felspar. Iron-oxides and some small sphenes are present. The rock may be named a diabase, probably forming dykes.

Mr. Lynch brought back about a dozen specimens representing rocks which had attracted his notice during the rest of his journey, the majority being limestones from the neighbourhood of Lake Van. But as he returned to this district during his second journey, I have transferred my description of them to Mr. Oswald, with the exception of two specimens of a serpentine which my interest in that rock induces me to publish. One, with the label "On the road behind Akhtamar (Lake Van)," is a dark-green serpentine with some lighter streaks and with oblique slickensided surfaces, sometimes partially coated with cream-coloured or green steatite, giving to the specimen a rather lenticular form. Under the microscope the serpentine indicates severe crushing (the flaky minerals often resembling antigorite), and contains a few much altered bastite crystals and powdered magnetite, more or less in streaks. It must originally have been a Saxonite, and in its present condition could be matched from several parts of the Alps. The other is labelled "Erzerum–Trebizond. Gorge beyond Pirnakapan. Kop Dagh."[1] It is a dark rock with an external steatitic film, generally greenish-white, but assuming a blue tinge where very thin. The specific gravity is 2·72. Microscopic examination shows it to consist of olivine partially changed into serpentine, bastite, in parts replaced by a mineral with slightly oblique extinction (? tremolite) or a minute fibrous one transverse to and obliterating the cleavages, magnetite in grains and occasionally in a powder (perhaps the latter sometimes hematite). The olivine is less altered than the bastite, for the former in most parts is only in the first stage of change, thin strings of serpentine occupying the cracks. Thus the rock is a partially serpentinized Saxonite not materially affected by pressure.

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[1] See Lynch, "Armenia," vol. i, p. 414 et seq., and vol. ii, p. 384.

IV.—On the Age of the Gebel Ahmar Sands and Sandstone, the Petrified Forest, and the Associated Lavas between Cairo and Suez.

By T. Barron, A.R.C.S., F.G.S.

[Published by permission of the Under-Secretary of State for Public Works, and the Director-General of the Survey Department, Egypt.]

The geological age of these beds has been the subject of much speculation by various geologists. In 1845 Orlebar[2] claimed to have found the Gebel Ahmar Sandstone at No. 3 Station on the Old Post Road to Suez, overlying Miocene beds containing *Scutella Zitteli*. O. Fraas[3] in 1867 imagined he could trace a gradual passage between the Upper Moqattam and these beds, and concluded, therefore, that they were of marine origin and Lower Oligocene age, as they had undergone the same general earth-movements as the Eocene beds.

Dr. Schweinfurth,[4] discussing the age and origin of these beds, says that there are two reasons for concluding that they are not marine: (1) they occur at different levels in various localities, and (2) they rest on a very uneven surface which does not differ much from the present-day relief. He, in fact, considers that the present-day relief of the surface had already been inaugurated before these beds were laid down. He also calls attention to the resemblance existing between the Pliocene sands in the Nile Valley and these beds, and finally groups them together in his map as (?) Pliocene.

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[1] Lynch: "Armenia," vol. ii, p. 229.

[2] "Some observations on the Geology of the District between Cairo and Suez": Journ. Roy. Asiatic Soc., 1845.

[3] "Aus dem Orient," 1867, pp. 157–8.

[4] "Geol. Schichtengliederung d. Mokattam": Zeitschr. d. Deutsch. Geol. Gesells., 1883, p. 719 et seq.

Discussing O. Fraas's views, he objects to the theory of a gradual passage from the Upper Moqattam into Gebel Ahmar beds, because there is no evidence of limestone and clay in the latter, and further that they have no affinity with the Moqattam beds, but closely resemble the Pliocene sands at the foot of the Moqattam. He found also on examining them that they did not overlie the uppermost beds of the Upper Moqattam, but in different places overlaid different beds at varying levels. This to Dr. Schweinfurth's mind was a proof of the fresh-water character of the deposit.

After discussing the evidence for and against the idea that the trees in the Petrified Forest have been silicified *in sitû*, he concludes that they have in all probability been transported to where they now lie, and subsequently petrified. The reasons adduced are as follows :—

1. All the trunks are horizontal; Figari Bey alone is reported to have found one erect.
2. No bark has been observed on the trunks, therefore they have not been silicified before being decomposed.
3. Many trunks appear to have been enclosed in the sand after silicification.
4. No branches or roots have been found in the district near Cairo.
5. Stems have been found with only nodes on them.

This author points out that there is an absence of stratification in the beds, and concludes that petrification must have taken place in a series of basins, because of the difference of level between the places at which the trees are found.

Professor Sickenberger[1] considered the Gebel Ahmar beds to be of Miocene age. Professor Mayer-Eymar[2] says that after the Lower Tongrian sea had retired and the volcanoes had become extinct, the country became covered by dense forests of trees for the most part of the order Sterculiaceæ and the species *Nicolia Ægyptiaca*, Unger. Then the subterranean waters, arrested either by the Senonian fold of Ataqa-Abu Roash or by internal volcanic masses, and heated by the latter, burst out to the right and left below the river of that period, and in the form of warm silicious springs bathed the foot of the trees wherever there was any depression. The trees were thus silicified *in sitû*. According to this author the age of the Petrified Forest is later than that of the basalt. He is of opinion that Gebel Ahmar is not the product of geyser action, that geysers did not exist, and that the various peaks of quartzite are in each case the product of a strong thermal spring.

M. Fourtau[3] regards Gebel Ahmar and Kreibun as the product of true geysers, and assigns them and the Petrified Forest to the Pliocene period.

Dr. Blanckenhorn[4] considers that geysers such as those of

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[1] Three lectures on the Geology of Egypt, 1891.

[2] Bull. de l'Institut Egyptien, 1893, pp. 393 et seq.

[3] "Etude géol. sur le Gebel Ahmar" (l'Institut Egyptien, Decembre, 1894); and "L'age des Forêts pétrifiées des déserts d'Egypte" (Bull. Soc. Khéd. Géographie, sér. v, No. 2, 1898).

[4] "Das Oligocän": Zeitschr. d. geolog. Gesells., 1900, pp. 477 and 478.

Yellowstone Park were not necessary to the formation of Gebel Ahmar Sandstone; hot springs were capable of doing all that is required. He imagines dunes and marshes, fresh-water basins or lagoons containing silica, and sand which was borne by fluviatile or æolian agencies and disposed in an irregular manner in the neighbourhood of the springs. This was cemented together by the silica contained in the water. This author regards the Gebel Ahmar Sandstone as Oligocene, while the silicified forests he makes Lower Miocene in many places.

It is now necessary to give the views of the present writer regarding the age of the beds in question. In the neighbourhood of Cairo there exists an area covered with petrified trunks of trees which is known as the Petrified Forest. These tree-trunks, now lying on the surface, have been exposed by the removal of the sands, etc., in which they were originally embedded. There is no evidence for the idea that these trees were silicified *in situ*; there is little doubt that they have been carried thither by a river and deposited in an estuary or lagoon.

The beds in question, if traced northwards, can be seen to disappear under the thin sheet of basalt underlying the Lower Miocene beds. This is the case in every place in this district where these two formations are seen in contact.

As a proof that the silicification of the tree-trunks did not take place at the time they were deposited, one may point to the entire absence of bark in every instance, the complete lack of remains of leaves and branches, and in many instances the marks of decomposition in the trunks which must have taken place prior to silicification. Another proof is the fact that the thermal springs were subsequent to the outpouring of the basalt. Evidence of this is seen in Gebel Gafeisad or Agleiat Qamr (a volcanic neck), where the hard plug of silica filling up the throat of an old thermal spring stands right in the centre of what was the neck of the volcano. From this radiate hard veins of silicious rock which are the infilling of fissures out of which welled the warm silicated waters which did the work of petrification.

North of Dêr el Bêda, the ruined palace of one of the Pashas, there occurs another volcanic neck, with a large dyke-like mass of quartzite running through it, which is undoubtedly the result of the plugging up by sand and colloid silica of a fissure up which the silicated waters rose. Round these two places numerous examples of plugged fissures are seen, while a certain area of the sand around has also been consolidated.

To the north-east of Bir Gendali and about 10 kilometres down Wadi Gendali there occurs what appears to be an injected fissure out of which basalt issued at one time. Connected with this, and standing out in relief, is the plug of a geyser or very large thermal spring opening. Here the relations between the basalt and the silicious rock are the same as those observed at the other places above mentioned, that is to say, the basalt was prior to the formation of the silicious plugs. It is interesting also to notice that in the neighbourhood of volcanic vents these injected fissures or plugs of hermal springs are much more numerous. It is also significant hat only in the neighbourhood of these thermal fissures does silicified wood occur in abundance.

In the foregoing paragraphs it has been indicated that the order of succession of the beds in question is, first, the floating in and depositing of the trees in a shallow estuary or lagoon; second, the pouring out of the basalt; and third, the breaking out of thermal springs containing silica in solution which petrified the trees in the sands. It might be maintained that the order of succession is not clearly proved between the basalt and the thermal springs. To this the answer is that it would be impossible for a geyser to coexist with an active volcano, and that if it were prior to the volcano the silica deposited by it would have been dissolved and absorbed by the igneous rock.

The history of these beds appears to be as follows:—After the deposition of the sands, etc., containing the trees, a series of earth-movements took place which culminated in an outburst of basalt on both sides of the present Nile Valley. When the force of the outburst had expended itself, the volcanoes, which had not (as far as one can see between Cairo and Suez) poured out very thick sheets of lava, became quiescent, earth-movements continued which threw the rocks into shallow basins, fractured the volcanic necks, and eventually opened a way for the outpouring of heated silicated waters. These waters issued sometimes undoubtedly in the form of a geyser, although in the majority of cases they came out in the form of hot springs. Over the surface of the basalt they flowed, penetrating the cracks and filling them with chalcedonic silica, many of these infillings being now seen standing out in relief on the surface of the decomposed basalt. The silicated waters gradually filled up the basins, and in process of time the trees which had already begun to decay in the loose sands in which they were lying, became silicified in the form in which they are now found.

Various writers have asserted that there were thermal springs during Lower Miocene times, but there is no evidence for this. The remains of plugged fissures are seen sticking up in Lower Miocene deposits, but the fact that no alteration of those beds is discernible, while in every instance where they occur in the Oligocene the sands are consolidated round them, to the writer's mind effectually disposes of this contention. Dr. Blanckenhorn[1] makes the age of the basalt on the east side of the Nile Valley to be Lower Miocene, while he assigns an Oligocene age to most of the silicified wood. The evidence is all the other way, and the onus of proof rests with him. As has been shown in a recent paper by the writer,[2] this basalt underlies in a discordant manner beds of Lower Miocene age, and it is therefore plain that the age of this lava is older than Lower

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[1] Loc. cit.

[2] Geol. Mag., 1904, pp. 603–608.

Miocene. Nor is it likely that a basalt outburst on one side of the Nile Valley should be of Lower Oligocene age, while a similar flow of lava on the other side is of Lower Miocene age, yet this is what Dr. Blanckenhorn states in his work previously quoted.

From what has been said, however, it would appear that a definite sequence of events has been established, and the following summary may now be made of the conclusions arrived at by the writer.

1. The Petrified Forest has not been silicified *in situ*; the trees have been brought from a distance by a river and deposited in a shallow lagoon or estuary.

2. The trees were not silicified immediately on deposition; they lay embedded in the sands for some time and underwent some decomposition, as is witnessed by the total absence of bark, branches, and leaves, and by the irregular and pitted exterior of the trunks, which must represent the external condition of the trees when the petrifying waters reached them.

3. After the deposition of the sands in which the trees were embedded had practically ceased, there was an outbreak of basalt which covered a good part of the beds.

4. After the volcanic action had ceased, earth-movements produced fissures up which warm silicated waters rose in the form of geysers and hot springs. The volcanic necks were fractured, and eventually the fissures thus produced were filled up by plugs of quartzite or chalcedonic silica, the surrounding rocks were thrown into shallow basins by two sets of folds, and the silicated water which collected in these basins silicified the trees lying in the sands.

5. When the geysers and hot springs had died out, a good deal of denudation took place; the hard plugs representing the throats of the springs were left standing out in relief; and when the Lower Miocene sea (first Mediterranean) invaded this district from the north-west, it deposited its sediments round these stumps and produced the appearance which has led some observers to the conclusion that the geysers occurred at that period.

6. The age of the Petrified Forest, the Gebel Ahmar Sands and Sandstone, and the associated lava-flows, is undoubtedly Oligocene, as these deposits fall between Eocene and Lower Miocene beds.

V.—On a specimen of *Cyrtoceras* (*Meloceras*) *apicale* from the Carboniferous Limestone, Kniveton, Derbyshire.

By G. C. Crick, F.G.S., of the British Museum (Natural History).

(PLATE III.)

THE specimen which forms the subject of the present communication is a fragment of a Nautiloid in the collection of Dr. Wheelton Hind, F.G.S., from the Carboniferous Limestone, Kniveton, Derbyshire, that seems to be referable to *Cyrtoceras* (*Meloceras*) *apicale*. This species, instituted by Dr. Foord in 1898,[1]

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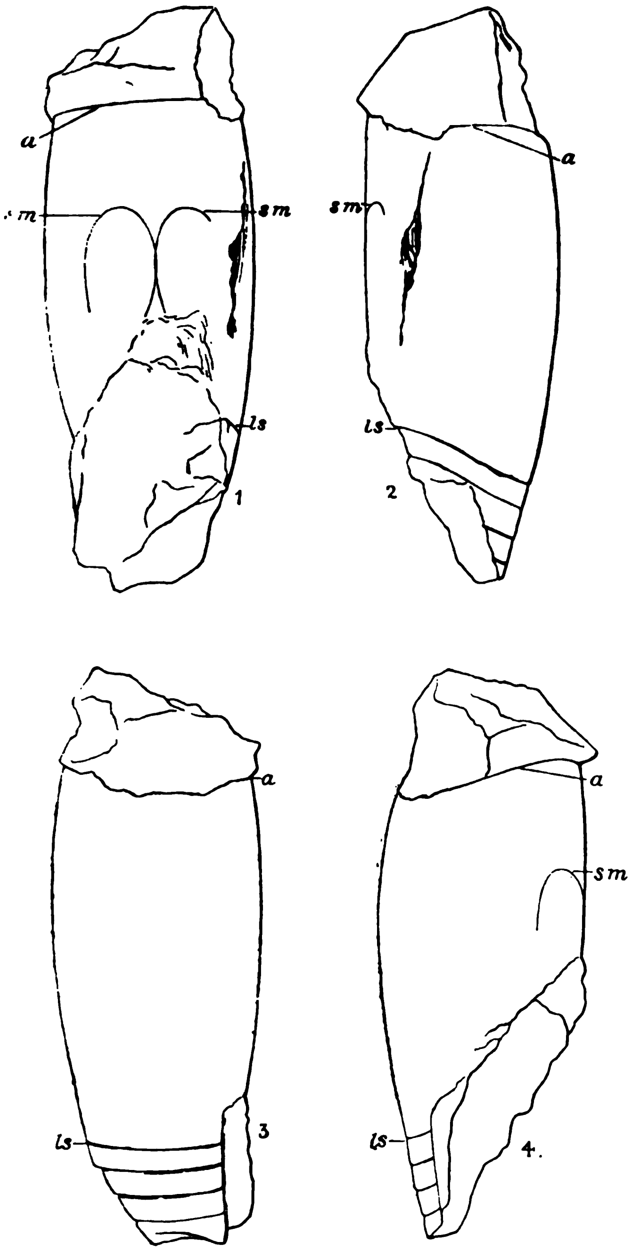
[1] Monograph of the Carboniferous Cephalopoda of Ireland (Palæontographical Society), pt. ii, 1898, pp. 33–36, pl. xi, figs. 1*a*, 1*b*, 2*a*, 2*b*, 3; pl. xii.



Cyrtoceras (*Meloceras*) *apicale*, A. H. Foord.
Carboniferous Limestone : Kniveton, Derbyshire.

and based upon examples from St. Doulagh's, co. Dublin, Ireland, was characterized as follows:—

"Shell of moderate size, rather sharply curved in the lower third of the septate portion, but becoming almost straight above this, so that a fragment consisting only of the upper two-thirds of the shell would scarcely exhibit any curvature. Upon a chord of 38 mm. subtending the concave side of the apical region of the shell the greatest curvature is 5 mm. The rate of tapering above this curved part is about 1 : 4, which is a rapid increase in diameter. The section is very nearly circular, the siphuncle close to the margin of the outer curvature of the shell. The body-chamber considerably exceeds one-third of the length of the entire shell; its basal line is indicated by the letters *a*, *b*, in fig. 2 of pl. xii, in which its obliquity is very marked, making an angle with the horizontal axis of the shell of about 18°. The septa are numerous, and being tilted up in a ventro-dorsal direction the sutures have a strong obliquity on the sides of the shell, while they are nearly horizontal on the ventral and dorsal aspects, perhaps with a slight arching upwards on the dorsal aspect (pl. xii, figs. 1*a*, 1*b*). The distance between the sutures in an adult shell (pl. xii, fig. 1*b*), where the diameter is about 50 mm., is from 5 to 6 mm.; in a somewhat smaller example (pl. xii, fig. 3) the sutures are 4 mm. apart where the diameter is 15 mm., 6 mm. apart where it is 37 mm. In a smaller specimen (pl. xi, figs. 2*a*, 2*b*), which is entirely septate, there are twenty-two septa within a distance of 106 mm. The chambers must thus have been very shallow. Exactly in the median line of the ventral aspect, or outer curvature of the shell, there is a straight thread-like line or keel, feebly developed, but clearly perceptible when the surface of the cast has not been abraded; it is represented rather too broad in the figure (pl. xii, fig. 1*b*). The siphuncle is exogastric—that is, it is situated close to the convex or ventral border of the shell; it is strongly inflated in passing through the chambers (pl. xii, figs. 3, 4*a*, 4*b*), casts of it presenting the characteristic bead-like appearance as in the last figures referred to.

"The surface of the shell is perfectly smooth.

"The approximate measurements of the most complete specimen give length 190 mm., greatest diameter of body-chamber 53 mm., diminishing to 48 mm. at or close to the aperture, and 6 mm. near the apical extremity."

The specimen in Dr. Wheelton Hind's collection from Kniveton consists of the internal cast of the greater part of the body-chamber, and of the ventral portion of the four preceding chambers (see Plate III, Figs. 1–4, p. 63). The body-chamber has a mean length of 73 mm., and is slightly curved; it attains its greatest diameter at about one-third of its length from the aperture, the ventro-dorsal and transverse diameters here being 43 and 44 mm. respectively; it gradually tapers both towards the aperture, where its ventro-dorsal and transverse diameters are 40 and 42 mm. respectively, and towards the base of the body-chamber, which is imperfect dorsally but has a transverse diameter of 34 mm. Part of the aperture is

·eserved; this appears to have been simple and nearly parallel the base of the body-chamber. The septa are oblique, tilted › on the dorsal side; the chambers are shallow, the sutures being ›out 5 mm. apart at the middle of the ventral aspect, or outer ırvature of the shell. There is no thread-like line or keel in the ntre of the ventral aspect. The siphuncle is not clearly shown; seems to have been inflated between the septa and to have been :ogastric, i.e., situated near the ventral surface of the shell. The st is not preserved.

The characters of the specimen agree so closely with Foord's *yrtoceras* (*Meloceras*) *apicale* that I think it may be correctly ferred to that species. Hitherto the species has been recorded ıly from the Carboniferous Limestone of St. Doulagh's, co. Dublin.[1] r. Hind's fossil is interesting, therefore, as showing the occurrence ' the species in this country also. It possesses additional terest from the fact that it partially exhibits the form of the uscular attachment of the animal to its shell. In the middle of e less convex (or dorsal) surface of the body-chamber there are ›rtions of two elliptical longitudinally-elongated areas,[2] each about 3 mm. wide; they touch each other in the median line of the ›ntral surface at a point 33 mm. below the edge of the aperture, ırt of which is also well shown in this fossil. Their anterior ›rders are 23 mm. from the edge of the aperture; both areas are ıperfect posteriorly owing to the imperfection of the specimen, and r the same reason their exact position with reference to the last ptum is not indicated, but it is estimated that the point at which ıese two elliptical areas meet was about 23 mm. in advance of the st septum, their anterior borders being about 10 mm. nearer the argin of the aperture. These elliptical areas are evidently the ıpressions (on the natural internal cast) of the muscle-scars that :isted on the internal surface of the dorsal portion of the shell. he condition of the surface of the specimen prevents us from cognising any indication whatever of the band connecting these ro areas across the ventral surface. They are exactly comparable ith the muscle-scars previously described in the genus *Amphoreopsis*.[3]

EXPLANATION OF PLATE III.

Cyrtoceras (*Meloceras*) *apicale*, A. H. Foord.

o. 1.—Dorsal aspect, exhibiting portion of peristome or margin of aperture (*a*), and part of the boundaries of the two muscle-scars (*sm*), *ls* being (in all the figures) the last septum or base of the body-chamber.

, 2.—Right lateral aspect, showing part of the peristome (*a*) and a small portion of the boundary of the right muscle-scar (*sm*).

, 3.—Ventral aspect, showing a portion of the margin of the aperture (*a*).

, 4.—Left lateral aspect, displaying part of the margin of the aperture (*a*) and the boundary of the left muscle-scar (*sm*).

Carboniferous Limestone: Kniveton, Derbyshire.

the collection of Dr. Wheelton Hind, F.G.S. All the figures are drawn of about three-fifths the natural size.

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[1] A. H. Foord: Mon. Carb. Ceph. Ireland (Pal. Soc.), pt. ii, 1898, p. 36.

[2] A portion of the boundary of each area is indicated by a very obscure feebly-ıpressed line.

[3] G. C. Crick: Proc. Malac. Soc., vol. vi, pt. 3, Sept. 1904, pp. 134–7, pl. viii.

VI.—ON A NEW TORTOISE FROM THE LOWER HEADON BEDS OF HORDWELL, *NICORIA HEADONENSIS*, SP. NOV.

By REGINALD W. HOOLEY, F.G.S.

THE bones of the carapace and plastron from which this species has been determined were discovered in a thin seam of grey sand intercalated in the Mammalian band of the Lower Headon Beds at Hordwell, Hampshire. They were lying scattered over an area of about four feet. The broken edge of the entoplastral and right hyoplastral were sticking out of the cliff face. The sea had carried away the missing portions of these bones and probably those lost of the carapace and plastron.

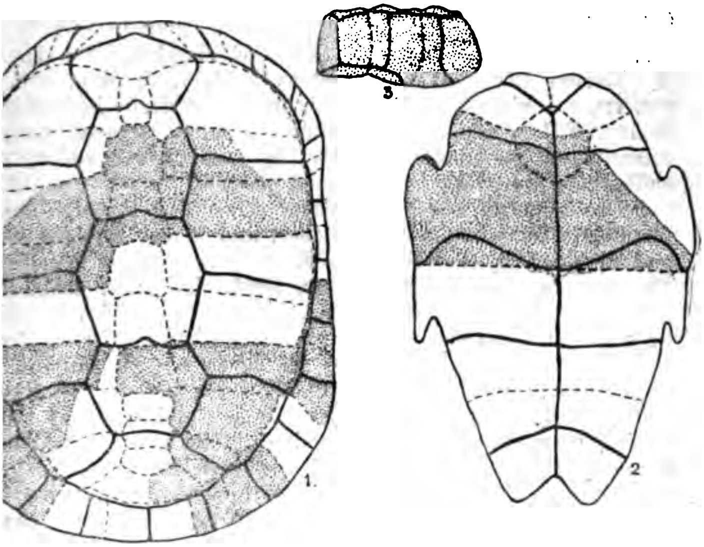
The illustration is from a photograph of an attempted restoration in plaster. The discovered bones are shaded, and from these the missing plates can easily be restored; the portion of the carapace anterior to the second neural is alone doubtful.

Of the plastron the character of the hyoplastrals is of course clear, and the remainder worked out from its nearest allies. The carapace, were it not for its posterior broadening, would be very ovoid; indeed, the line of the costal and marginal suture is quite ovate. It probably measured 19 mm. in length. It is well vaulted, with a slight depression posteriorly where it becomes expanded. There is no discernible carination, and the marginals are not serrated.

Of the carapace, the bones found consist of the second, third, and sixth neurals, and the right half of the second supra-pygal. The proximal end of the second, the whole of the third, sixth, seventh, and eighth costals of the right, a piece of the third, the entire fourth and sixth, and the distal end of the seventh costal of the left. The seventh, eighth, tenth, and eleventh marginals of the right, and the fourth, fifth, sixth, eighth, ninth, and tenth of the left. Of the plastron, the greater portion of the entoplastral, a small moiety of the anterior end alone being destroyed. A part of the right hyoplastral and the whole of the left.

The neurals have their short sides placed posteriorly. The second is octagonal and the third and sixth hexagonal, and judging from the proximal ends of the neighbouring costals the fourth and fifth are hexagonal and also symmetrical with the third and sixth. The surfaces of the second neural sutures with the first costals are not on a plane, but concave, the left showing a greater depression than the right, but this is doubtless an individual trait. As evidenced by the sulcus, the vertebral shields were hexagonal with a small projection in the centre of the anterior margin. The posterior border of the fifth slopes downwards to the sulcus on the eleventh marginal, whence it apparently crosses the pygal on the same horizon. The vertebrals are nearly as broad as long, but compared with the costals narrow. The latter are much longer than broad. The posterior marginals are slightly fluted parallel to their edge.

The plastron is strongly united to the carapace by suture. On the seventh marginal there is a very powerful inguinal buttress, which from the prominence of its ridge at the marginal suture nds on to the fifth costal. The entoplastral bone is rounded eriorly and intersected by the humero-pectoral sulcus, which rses the plastron in a sinuous line. The pectoral-abdominal s touches the posterior hyoplastral suture at the right angle, ed with the median suture; from here it gradually curves ards to the height of about a quarter the length of the hyoplastral, it rapidly falls, passing from that plate at the point of union he outer and lateral posterior suture; this sulcus becomes arkably deep in the central region of the plastron, forming y marked feature.



Shell of *Nicoria headonensis*, sp. nov.
1, shell (carapace); 2, plastron; 3, part of the inguinal buttress.
From Lower Headon Beds, Hordwell, Hants.

his specimen comes within the family Testudinidæ by the lete ossification of the shell, the union of the plastron with arapace by suture, the ovoid character of the carapace, and its ing of epidermal shields. Further, from the neural plates g short-sided behind, and the entoplastron intersected by the ero-pectoral sulcus, it may be referred to the genus *Nicoria*, as ged by Mr. Boulenger in his synopsis of the genera of this y in the British Museum Catalogue of Chelonians. The second l bone and the general form of the vertebral and costal shields a strong resemblance to the recent *Nicoria trijuga*; but it s in not having its fifth neural bone octagonal, and its sixth -sided in front. It also differs from *Nicoria tricarinata* (from Pliocene of the Siwalik Hills) in the carapace not being so ately oval, in exhibiting no carination, and in the form of the bral and costal shields. It is also distinguished from its variety *sivalensis* by the same characters, and by the plastron being connected to the carapace by suture and not by ligament.

Apparently the fossil now described represents a new species; it would therefore be well to designate it *Nicoria headonensis*. This, we believe, is the first record of the genus from England. At the present day *Nicoria* is found in the East Indies and Central and South America.

NOTICES OF MEMOIRS, ETC.

On the Significance of Pneumatic Foramina in Fossil Bones.

In a paper "On a Pneumatic Type of Vertebra from the Lower Karroo Rocks of Cape Colony" (Ann. & Mag. Nat. Hist., ser. vii, vol. xiv, November, 1904, pp. 336–344), by Professor H. G. Seeley, F.R.S., the author makes (on p. 341) some interesting remarks on pneumatic foramina in fossil bones which appear sufficiently important to reproduce here:—

"Doubt has of late been current concerning the significance of pneumatic foramina in fossil bones, and is put forward verbally and in print by Professor H. F. Osborn. In an article in the *Century Magazine* for September, 1904, similar in scope to the lecture given at Cambridge in August to the British Association, he enunciates the same views. Writing of *Ornitholestes*, Professor Osborn remarks:—'Externally its bones are simple and solid-looking, but, as a matter of fact, they are mere shells, the walls being hardly thicker than paper, the entire interior of the bone having been removed by the action of the same marvellous law of adaptation which sculptured the vertebræ of its huge contemporaries. There is no evidence, however, that these hollow bones were filled with air from the lungs, as is the case of the bones of birds.'

"*Ornitholcstes* is compared with *Cœlurus, Hallopus, Ornithomimus*, and *Aristosuchus*. It is known from the skull, forty-five vertebræ, pelvis, and representative parts of both fore and hind limbs of one individual (Bull. Am. Mus. Nat. Hist., vol. xix, p. 459). But from the context quoted I gather that the author's conclusions should be applied, not only to *Ornitholestes*, but to the pneumatic vertebræ of the largest Dinosaurs, possibly to all fossil pneumatic bones which are not referable to birds.

"The current belief that a pneumatic vertebral column is evidence of the prolongation into the bones of air-cells from the lungs is an inductive conclusion, based upon the evidence from the parallel condition in the bones of birds. This evidence is affirmed by Professor Osborn, in the passage quoted, not to exist, and in place of it he offers what is termed the 'Law of Adaptation' as having sculptured these huge vertebræ. I have met with no enunciation of this law; and until it is explained how it differs in physiological action from the processes which sculpture or excavate the bones of birds, it will be difficult to judge whether we are offered a law, a suggestion, or only words, for no law will produce anatomical effects without corresponding physiological circumstances to sculpture the bones.

"If the influence of pneumatic pressure produces a well-known osteological result in excavation of a bone in a bird, what is there in the vertebræ of a Dinosaur to suggest that similar effects have been produced by dissimilar causes? And it would be interesting to find in an extinct order of animals evidence that an agency unconnected with the lungs produced results which differ from those in birds only in being the effect of larger areas of pressure acting laterally upon the sides of the vertebræ. But the evidence that there was any essential difference in the origin of these structures in Dinosaurs and birds is not forthcoming; and if it ever existed is lost with the soft parts of the animal.

"Nevertheless, cavities are formed in certain bones in animals of varied organization, which are not connected with the lungs in the manner of air-cells of birds, but they are chiefly in the skull. They are slightly developed in existing reptiles, but are most conspicuous in warm-blooded animals. The skulls of elephants exhibit a maximum development of pneumatic cavities which have no connexion with the lungs, and the texture of these bones closely approximates to that of cellular vertebræ in some Cetiosaurian Dinosaurs, such as *Ornithopsis* and its American representatives. The resemblance between the mammal skull and the reptile vertebra is one of analogy. There are no facts to support the inference that the cause which *expanded* the cranial bones of the elephant and other mammals is identical with that which absorbed and excavated the bony tissue, but did not augment the size of the cervical and dorsal vertebræ of Dinosaurs. There is no basis for comparison between the conditions in mammals and these extinct reptiles, for no mammal shows a pneumatic vertebral column which can be compared with these Dinosaurs; and when a mammalian vertebra is hollow it is not comparable, since there is no pneumatic foramen.

"On the other hand, Dinosaurs are not conspicuous for pneumatic cavities in bones of the skull, and there are therefore no facts to suggest the idea that they might by analogy develop a pneumatic vertebral column which was not connected with the lungs, even if the cranial and vertebral pneumatic structures had been comparable.

"The influence of the lungs as a whole in modifying the vertebral column of a reptile is manifest in the dorsal vertebræ of Testudinata. In tortoises, under conditions of terrestrial life, the lungs have expanded and given the carapace a remarkable elevation. At the same time the neural arches have become raised, and the lungs have pressed evenly against the sides of the centra of the vertebræ till they have become narrowed into thin plates by the tissue being absorbed laterally. But the lung never penetrates into the substance of the vertebra or excavates holes in the bones in existing reptiles comparable to those seen in skeletons of Dinosaurs, Ornithosaurs, and birds.

"The influence of the lungs on the vertebral column of a Dinosaur as distinct from the air-cells may be, perhaps, inferred from the elevated condition of the neural arch and upward direction of transverse processes under which the lungs extended in such a type as *Diplodocus*, described by Professor Osborn and the late Dr. J. B. Hatcher. It is reasonable to infer that the lungs were so large that their intermittent upward pressure stimulated the growth of the neuro-central suture to form the high neural arch; but as they were not confined by an unyielding envelope in the same way that the carapace confines the lungs of tortoises, there is but little lateral compression of the body of a vertebra as a consequence of absorption, which was localized laterally about the pneumatic foramen.

"All down the vertebral column in *Diplodocus* the vertebræ are excavated, and the lateral holes were termed by Dr. Hatcher pleuro-central cavities. They have been well described in *Ornithopsis*. Their distinctive feature is that in the dorsal region the lateral foramina expand within the centrum into large chambers separated by a median vertical longitudinal partition, and each is commonly divided into unequal anterior and posterior parts by an imperfect vertical transverse lamina of bone. From this primary lateral cavity bone-cells commonly extend to the articular faces of the centrum and other parts of the vertebra. This condition of the pneumatic vertebræ is only dissimilar to that of birds in its details. In no existing animals except birds is a similar pneumatic structure found in the vertebral column, and it is only known in connexion with air-cells prolonged from the lungs. There is no fact to suggest that the lungs themselves were extended into the pleuro-central cavities of Dinosaurs: such an idea is not consistent with the pneumatic condition of the vertebræ in the elongated neck and tail. But with the general resemblance to the condition in the bones of birds it has been inferred that the pneumatic pressure, which was persistent enough to absorb the bone locally and laterally, was greater in Dinosaurs than in birds, because the cavities excavated are larger. Although this pressure, judged by its effects, was most potent in the dorsal region of the lungs, it also extended to the neck and tail, as in certain birds. It is therefore inferred that no cause is known except prolongation of air-cells from the lungs into the bones which is capable of producing these results, for from no other source in nature is the pressure derived which penetrates in this way into the skeleton.

"This is inductive evidence from physiology and comparative anatomy. In place of it Professor Osborn has offered nothing except the following passage:—'The dominating principle in construction of the backbone is maximum strength with minimum weight. The ingenuity of sculpture by which this is brought about, every single vertebra differing from its fellow, baffles the Lamarckian as well as the Darwinian, and tempts us to revive the old teleological explanation.'[1] Teleology is not known as an element in science, and explains nothing."

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[1] Memoirs American Museum of Natural History, vol. i, part 5, p. 193, "A Skeleton of *Diplodocus*."

REVIEWS.

.—Geological Survey of Canada. Robert Bell, M.D., Sc.D., LL.D., F.R.S. Annual Report, Volume XIII: Reports A, D, DD, F and FF, K, L, M and MM, R, S. 1900. 8vo; pp. 747, xvii, 15 plates, figures, and 8 maps. (Ottawa: S. E. Dawson, 1903.)

HIS volume is in the usual form of a number of independent reports, each distinguished by a letter and separately paged, hich have been issued previously as completed. It is presumed refer to the operations of the Survey to the end of the year 1900, t some of the reports are based on observations not made till 1901. The first Report (A), extending to 203 pages, contains a general mmary of the Survey work for 1900. It was drawn up and bmitted by the late Director of the Survey, Dr. G. M. Dawson, in nuary, 1901, and was probably his last piece of official work, for s death took place in the March following.

Beginning in the extreme north-west of the Dominion, mention is st made of the exploration by Mr. R. G. McConnell of the valley the Stewart River and of a part of the Yukon, of which it is tributary. The country bordering the rivers is mountainous; the cks are of granite, granite-gneiss, quartz and hornblende schists, d crystalline limestones, overlain by dark siliceous slates. On e Klondike River there are outcrops of soft shales and sandstones ith beds of lignite, which is mined for heating purposes. These ds are probably of Tertiary age.

In British Columbia, the further investigations of Mr. J. C. willim, in the mountainous district between the Atlin and Teslin kes, show that the rocks are mainly of quartzite, limestone, and eenstone, whilst at lower levels there is a great thickness of ndstone, apparently Cretaceous in age. In the Districts of East d West Kootenay, work was carried on by Mr. R. W. Brock and r. J. McEvoy, and a report of the Crow's Nest Coalfield, west of e summit of the Rocky Mountains, shows that in this district nestones containing *Productus* are succeeded by Cretaceous conomerates, shales, and sandstones, with beds of coal, in an parently continuous section 5,000 feet in thickness.

In the Mackenzie District, at the far north, Mr. J. M. Bell plored the regions between the Great Slave and the Great Bear kes, following the Mackenzie and Bear Rivers, and notes the esence of Archæan, Palæozoic, Cretaceous, and Tertiary rocks. und the Great Bear Lake there are wonderful examples of old ore-lines indicating the former extent of the lake. In some aces on the north-west side they are over 300 feet in height and 4 miles back from the present shore. Near the shore itself there e also broad beaches and terraces of pebbles from 10 to 100 feet in ight.

In the Province of Ontario, Mr. McInnes reports on the areas und Port Arthur to the international boundary, and Dr. R. Bell e present Director) gives the results of his survey of the

Michipoten District, including a description of the great mass of hematite ore at the Helen Mine.

In the Province of New Brunswick, Professor L. W. Bailey has determined the Ordovician and Silurian age of the rocks of the so-called great slate belt, and he has also contributed a separate report on the Carboniferous System of this Province with respect to the occurrence of workable coal-beds. The same subject is also treated by Mr. H. S. Poole, who arrives at the conclusion that to the north of the coastal range there are no equivalents of the productive Coal-measures of Nova Scotia, and that the prospects of any thick seams to the south of the range are similarly unfavourable.

In Nova Scotia, Mr. H. Fletcher has examined the south-western corner of the Springhill Coalfield and the Inverness Coalfield in Cape Breton.

Of the other reports in the volume, may be mentioned that by Mr. A. P. Low on the barren region bordering the east coast of Hudson Bay, from Cape Wolstenholme to the south end of James Bay. The northern and southern portions of the coast are of low, rounded hills of gneiss or granite, whilst the intermediate area consists of bold hills, 1,000 feet or more in height, of granite or trap. Argillites, greywackes, and cherts, associated with large masses of magnetite and hematite, and overlain by cherty carbonates of iron, magnesia, and lime, are likewise present. The series is capped by limestones, dolomites, carbonaceous shales, and sandstones. The sedimentary rocks are traversed by large vertical dykes of diabase, and subsequently by enormous irruptions of granite, which have considerably altered their characters. Fossil evidence of their age is wanting, but they are regarded by Mr. Low as pre-Cambrian. The geology of the basin of the Nottaway River, an extensive region lying to the south-east of James Bay, or between the Upper Ottawa and the Rupert River, was explored and partly surveyed by Dr. R. Bell in 1895–6, and in a brief report and on his map it is shown to consist largely of Laurentian gneiss with belts of crystalline schists, granites, and greenstones of Huronian age.

There is also a report by Mr. J. B. Tyrrel on the north-eastern portion of the Saskatchewan District and adjoining portions of the Keewatin. The greater part of these areas is underlain by Laurentian gneiss and granite and Huronian schists. Undisturbed limestones of Trenton and Niagara age overlie the older crystalline rocks, and these in turn are covered by Pleistocene (glacial) clays.

Further reports comprise an elaborate description by Mr. J. A. Dresser of the geology and petrography of Shefford Mountain, Quebec, illustrated by plans and figures. The mountain is considered to be of laccolitic origin. The report of the Section of Chemistry and Mineralogy by Dr. G. C. Hoffmann and his assistants, Messrs. Wait and Johnston, consists mainly of determinations of ores and rocks of but little general interest. The concluding report of the Section of Mines by Mr. E. D. Ingall and Mr. J. McLeish, extending to 160 pages, principally consists of statistics of the output and value of the metals, minerals, and structural materials obtained in the Dominion during 1900.

II.—The Recent Work of the Norwegian Geological Survey in the Hardanger District.

W. C. Brögger: "Lagfölgen paa Hardangervidda," Norges geologiske Undersögelse, 1893.
H. Reusch, J. Rekstad, and K. O. Björlykke: "Fra Hardangervidden," Norges geol. U., 1902.
H. Kaldhol: "Suldalsfjeldene," Norges geol. U., 1903.
J. Rekstad: "Fra höifjeldströget mellem Haukeli og Hemsedalsfjeldene," Norges geol. U., 1903.

THE Hardanger Vidde is a great desolate plateau with an average level of some 4,000 feet above the sea, situated east and south-east of the head of the Hardanger Fjord. It is dotted over with patches of snow, and one fairly extensive snowfield, the Hardanger Jökel, lies upon it. A glacier, the Rembesdals Brae, descends from the snowfield into a little mountain lake above the top of the waterfall Rembesdalsfos, but though the scene is one of great beauty it is seldom visited by the tourist, the path being very tedious and the climb up the rock near the waterfall somewhat difficult.

No part of the Hardanger Vidde, indeed, is well known to the foreigner, though there is a comfortable little hotel on its edge just above the great waterfall Vöringfos, and a few English find their way out on to the Vidde in search of sport.

Until recently the geology of the district was almost unknown, but now the Geological Survey of Norway have taken it in hand and several notices of their work have appeared in the Year Books. Still, these can only be looked upon as preliminary reports, for an extension of the survey further to the north is required to clear up some of the problems which have arisen. In the Year Book for 1903 there is, too, a short report on the geology of the mountainous tract which lies around the Röldal Lake, the Suldals Lake, and the Hyls Fjord, and this tract may fairly be treated as a southern continuation of the Hardanger Vidde District.

The geological formations found over the surface of the Hardanger Vidde and the Suldals Fjeld are as follows:—

Glacial and Recent.	Peat, Gravel and Sand, Moraines, Moraine Débris, Raised Terraces, etc.
Silurian.	(1) Mica Schist and Phyllite with subordinate beds of limestone.
	(2) Blue-grey Quartzite.
Cambrian.	Dark-coloured schists and slate.
Algonkian.	The Telemark Formation. Gneiss, Quartzite, Hornblende schist.
Archæan.	Gneiss.

Considerable masses of igneous rock are found associated with the above strata, and belong to at least three distinct periods—

A. Granite newer than the Silurian strata of the district.
B. Granite which was intruded between the date of the Algonkian and the Cambrian.
C. Igneous rock, mainly basic, now greatly altered and folded together with the Archæan Gneiss.

Up till recently the Norwegian geologists added another formation to the above list, placing it above what is now classed as Silurian strata, but it seems to be proved that the rocks assigned to that formation are in fact masses of the older granites, gneisses, etc., which have been thrust over the Cambrian and Silurian strata.

The result of the work of the Survey recorded in the published reports shows that the geological history of the district is somewhat as follows :—

Archæan.

The green and white gneiss so common in the adjoining districts is seldom found here in continuous masses below everything else. Mr. Rekstad records an occurrence some little distance eastward of the snowfield Hardanger Jökel and another on the north of the mountain Hallingskarvet. Patches of the old gneiss are, however, common, lying in or upon the granite B in the above list.

Mr. Björlykke mentions one such patch south of Skjaegge Dal on the east of the Sör Fjord. It lies upon the granite, and consists of greyish compact micaceous gneiss, sometimes with hornblende or chlorite, with layers of hornblende schist and also of a rock like saussurite gabbro. In places, too, there is gneissic granite, but the hornblende rock is the most common.

The Algonkian or Telemark Formation.

Rocks which are assigned to this formation are developed to a considerable extent along the Sör Fjord. They do not reach the head of the fjord at Odde, being cut off by the granite B a little north of that place. Fairly large areas of the Telemark Formation have also been found near Hallingskarvet in the north of the district and near the Hyls Fjord in the Suldals Fjeld. The formation consists of gneiss, sometimes fine-grained and passing into varieties resembling quartzite, of beds of quartzite, and of layers of hornblende schist. In places conglomerate occurs.

Associated with these rocks there are on the Sör Fjord massive rocks resembling saussurite gabbro in lens- or dome-shaped masses. The formation is penetrated by numerous granite veins which in places have been crushed into lens-shaped patches.

The Older Granite.

Both the Archæan Gneiss and the Telemark formation are, in the district of which we are speaking, to a great extent cut out by granite. This granite is older than the Cambrian and Silurian rocks of the district, for they are never penetrated by veins from it. The Telemark formation, on the contrary, is cut by granite veins in all directions.

The granite, according to Mr. Rekstad, often contains oligoclase as well as orthoclase, and this is more especially the case in the district north of the Hardanger Jökel. The mica is usually black, light mica only occurring to a small extent.

The granite is frequently porphyritic, and the rock is usually more or less gneissic, sometimes assuming the form of augen-gneiss. Pegmatite veins and also quartz veins run through it here and there, ncluded patches of basic rock, of the old gneiss, and of the ark formation are common.

e granite platform upon which the Cambro-Silurian strata rest of the striking features in the geology of the Hardanger Vidde. suggested by Mr. Rekstad that this platform may possibly be Cambrian surface of erosion, and in that case, as he points out, emarkable that it should have retained its horizontality through levation of the Scandinavian highlands and through the vast l which has elapsed since. It is, however, possible that it e a thrust-plane.

e surface of this platform is usually from 3,000 to 4,300 feet the sea so far as the Hardanger Vidde is concerned, and quently the magnificent sections which we see as we pass gh the valley of the fjord and its branches are in the granite, eiss, or the Telemark formation, and it is not until we emerge the valley on to the high ground of the Vidde itself that we to the Cambro-Silurian.

e most accessible place on the Hardanger Vidde at which the on between the granite and the overlying Cambro-Silurian e seen is the mountain Grytefjeld, above the head of the dal. If we mount up the zigzag path near the great waterfall gfos we see that mountain before us when we emerge from the . Its appearance is very remarkable. The lower and main s of a light colour, whilst on its top there is a dark cap. The coloured rock is the granite and the cap is the Cambro-Silurian. oundary between them at this point appears to be a thrust , for Dr. Reusch found that the topmost part of the granite liated parallel with that boundary.

some places the Cambro-Silurian strata rest upon old gneiss or Telemark formation, but the platform usually consists of granite. e Suldals Fjeld Mr. Kaldhol found a conglomerate which he ht might be the basement-bed of the Cambro-Silurian, but at me time he says it may belong to the Telemark formation, and he rest of the district there does not appear to be any basement merate to the schists.

laces there is at the bottom of the schists a bed of arkose-like one, and in others a bed of felspathic quartzite, in each case ning flakes and layers of schist.

The Cambrian.

Cambro-Silurian Series is divided into three divisions, the t of which is provisionally classed with the Cambrian and the pper with the Silurian. The lowest division consists of dark-ed schist not unlike the alum slate of the Christiania district. ck gives a black streak. It is much crumpled and contains quartz eyes. There is a good deal of finely disseminated s, which gives a yellow-brown colour to the weathered surface. not folded the thickness is from 90 to 150 feet. *Dictyonema iforme*, Eich., and traces of some other fossils have been in these black shales. In the Suldals Fjeld these black beds metimes wanting.

The Silurian.—The Blue-grey Quartzite.

On a great part of the Hardanger Vidde the black Cambrian schists are overlain by thickly bedded, blue-grey quartzite, in some places associated with a little calcareous sandstone. It is traversed by numerous veins of white quartz, often with cavities containing good rock crystals. The thickness of this quartzite varies from a few yards up to 180 feet. In some parts of the district it is absent, and in the Suldals Fjeld it appears to be represented by a greyish quartzite with schistose layers on the bedding-planes. A very similar blue quartzite is found in Valdres, Gausdal, and other districts of Norway, and Professor Brögger suggests that it possibly belongs to the lower part of Etage 3 of the Cambro-Silurian.

Above the blue-grey quartzite there is frequently a bed of grey or yellowish, rather fine-grained, crystalline limestone, containing flakes of mica and chlorite; these flakes become more and more numerous in the upper part of the limestone, until the limestone becomes a calcareous schist and finally passes into the overlying schists.

Professor Brögger suggests that this limestone may correspond to the Orthoceras Limestone which occurs at the top of Etage 3 in the Christiania district. This limestone in Hardanger Vidde attains a maximum thickness of about 30 feet. Apart from this limestone there is above the blue-grey quartzite a considerable thickness of schists of a very variable character, as a rule becoming coarser-grained in the upper beds. If the limestone above the blue-grey quartzite corresponds to the Orthoceras Limestone, then these schists will fall into Etage 4 of the Cambro-Silurian System.

The Great Thrusts.

The summits of the district are occasionally formed of the blue-grey quartzite, since owing to its hardness it has withstood denudation better than the schists, but the tops of the mountains and the high ground much more frequently consist of older and still harder rocks which have been thrust over the Cambro-Silurian.

We have mentioned that the Cambro-Silurian rests upon a remarkably even platform of granite and gneiss, but they themselves have been greatly crushed and folded, and it is probable that this crushing and folding were mainly caused at the time of the thrust movements, the soft schists and associated beds having been compressed between the old rock platform and the overthrust mass of hard granite and gneiss. In consequence it is found that, though the bottom of the schists is so level a plane, their top is often most irregular, being puckered and contorted with the overthrust mass. The most accessible place at which to study the relation of the overthrust mass to the other beds is the pass between Seljestad and Breifond, above the celebrated winding road known as Horrebrækkene. The succession is as follows:—

1. Overthrust mass of gneiss, granite, etc., forming the top of the mountain Horrehei.
2. Silurian schists, etc.
3. The black schists of the Cambrian.
4. Granite, gneiss, etc.

The overthrust mass contains not only the oldest granites and gneisses, but also masses of Telemark formation, and even some of the Cambro-Silurian schists, all folded up together.

These overthrust rocks were described by Kjerulf under the name Höiefjeldskvarts and by Brögger as the "Yngre Gneisformation," and the probability that their position is due to overthrusting was not definitely stated by those authors.

In the south-western part of the Hardanger Vidde there is a large area of the overthrust rock extending on the high ground from above Odde to above Röldal, and on a line parallel to the north-eastern boundary of this tract there is a row of high peaks, the lower part of each consisting of Cambro-Silurian and the summit of a mass of the overthrust rock. Mr. Rekstad found that these mountains capped with the blocks of overthrust rock rest each in a hollow in the Cambro-Silurian, for in every case he noticed on going round one of them the schists dip on all sides towards that particular peak.

The Younger Granite.

Hitherto it does not appear to have been known that any of the granite in this district was newer than the Cambrian, for though the Telemark formation is penetrated in all directions by granite veins none have hitherto been recorded as cutting the Cambro-Silurian.

Mr. Kaldhol has now, however, found that the granite of the Suldals Fjeld is of two ages, and on the south of the little lake by the Skardnut he noticed granite cutting the schists and altering them into hornfels. In other places there are bed-like patches of granite in the schists, in the neighbourhood of which there is a distinct false lamination, and small fragments of schist occur in the granite. This younger granite is of medium grain, with very little sign of foliation.

Faults.

The rocks of the district are intersected by numerous faults, and the influence of these faults on the surface features is discussed at some length. The valleys of the district may be divided into two classes: (1) the wide open valleys of the high ground; (2) the fjord-valleys, by which we mean the great valley of the Hardanger Fjord itself and its branches. The bottom of these fjord-valleys is now in part submerged beneath the water of the sea and in part above sea-level. In many cases the fjord-valley has been excavated along the bottom of one of the older wide open valleys of the high ground.

The river Bjoreia flows for many miles through one of the wide open valleys of the Hardanger Vidde, and at the great waterfall Vöringfos it plunges into a fjord-valley, the Maabödal.

In the Year Book for 1900 Dr. Reusch suggested that the position of the waterfall and the direction of the Maabödal were due to faults, cracks, or lines of weakness in the rock in which the valley has been cut; and in the Year Book for 1903 Mr. Rekstad deals with the part of the valley above the waterfall, giving evidence to show that it is due to faults running along both sides of the valley, and is in short what has been termed a 'block valley.' Several cases are instanced where a valley follows the line of a fault. Thus Rossemyrnut is capped by the Telemark formation, and Mr. Kaldhol believes that it is a sunken part, a line of fault following the valley, for the granite on the opposite side of Grubbe Dal rises to about the level of the summit of Rossemyrnut. In the Year Book for 1902 Mr. Rekstad gives an example of a valley on the line of a fault near Juklevasrusten, in the centre of the Hardanger Vidde; and in the Year Book for 1903 he gives another instance in Gjuvedal, a small valley a little north of and nearly parallel to the Maabödal, down which the Bjoreia flows.

The ice-marking, perched blocks, moraines, etc., of the Glacial Period, as well as the raised terraces, receive attention in these memoirs, and the whole work is well illustrated by a series of photographs taken for the most part by Mr. Rekstad, and very satisfactorily reproduced both as plates and in the text. In conclusion, we can confidently recommend the Hardanger Vidde as a most interesting district, not easy to visit, but with plenty of sections, though not infrequently, judging from the accounts of the surveyors, a critical point is apt to be an inaccessible wall of rock or concealed by snow or talus débris. H. W. MONCKTON.

III.—A HANDBOOK TO THE GEOLOGY OF CHELTENHAM AND NEIGHBOURHOOD. By L. RICHARDSON, F.G.S. 8vo; pp. xii and 268, with geological map, 19 plates, and 19 text-illustrations. (Cheltenham: Norman, Sawyer, & Co., 1904. Price 5s. net.)

THE Cotteswold Hills and the Vale of Gloucester have attracted a large amount of attention since Murchison and Lonsdale more than seventy years ago made known the general structure of the district, and stirred up interest in the rich fossil-beds of the Lias and the Oolites. During these years the steady increase of knowledge has been fostered by the Cotteswold Naturalists' Club, which numbered among its earlier workers such men as H. E. Strickland, James Buckman, John Lycett, P. B. Brodie, and Thomas Wright.

Murchison's "Outline of the Geology of the Neighbourhood of Cheltenham," published in 1834, was revised and augmented by J. Buckman & Strickland in 1845; Lycett's Handbook of "The Cotteswold Hills" and Hull's Geological Survey Memoir on "The Geology of the Country around Cheltenham" were issued in 1857; and Witchell's "Geology of Stroud" was published in 1882. A study of these works shows the increasing attention paid to the stratigraphy and palæontology of the Cotteswold Hills and bordering vales, while a kind of climax in minute subdivision of the local strata and of the fossil genera and species has been reached in the later works by Mr. S. S. Buckman. Inspired to a large extent by the teachings of that palæontologist, or we might preferably say field-palæontologist, Mr. Linsdall Richardson, who is Honorary

Secretary of the Cotteswold Naturalists' Field Club (as it is now termed), has given us the latest results of research in the fascinating region of Cheltenham. We may at once say that the work bears abundant evidence of his knowledge, diligence, and enthusiasm. He has brought together the available material that bears on the geology, and especially on the life-history of the local rocks from the Trias to the Forest Marble. We find consequently much information on the horizons of fossils, as well as on the zones, which, being based on palæontological evidence, are naturally independent of the ordinary limits of geological formations. The term *zone* is used to imply the deposits (of whatever character) of a particular period of time; while the term *hemera* is used to denote the time of a zone. As defined by Mr. Buckman the hemera is "the time during which a particular species—generally in Mesozoic chronology, of an ammonite—has dominant existence." With his aid the author enumerates 29 hemeræ for the Liassic series and 16 for the Inferior Oolite series. We should agree, however, with Mr. Hudleston in maintaining "the chronological value of Ammonite zones," and we prefer to consider the hemeræ as minor adjuncts of zones.[1]

It is evident that to follow the author much preliminary knowledge will be required. His work is an advanced rather than an introductory guide, and it appeals much more to the specialist than did any of the handbooks previously published. Thus, in describing the zone of *Schlotheimia angulata* (p. 40), he observes that "Beds usually referred to this zone have been found to have accumulated during two hemeræ—the hemeræ *megastomatos* and *marmoreæ*." We fail to find any explanation of these two hemeræ. There are many other hard nuts for the student to crack, if he be not specially instructed in the vicissitudes of palæontological nomenclature. No doubt the most difficult part of the author's work has been to employ the latest names assigned to the species he mentions. Thus *Ammonites raricostatus* (after three or four intermediate names) is now *Echioceras raricostatum*. The *Opalinum*-zone is duly noted, but we are by no means sure that any fossil corresponding to *Ammonites opalinus* is now recognized in the district, although included in the *Opalinum*-zone are the "*Opaliniforme*-beds" with *Cypholioceras opaliniforme*.

Here we may remark that we do not like the vague name "pre-planorbis beds," introduced by the author for the *Ostrea*-beds at the base of the Lower Lias. He finds fault with the term "White Lias," but it is a useful stratigraphical term for the Upper Rhætic beds in the region extending southwards from Bath.

The fact that zonal divisions often transgress the limits of ordinary stratigraphical divisions leads the author to speak of a "new school of geologists" who give "names to the time during which the beds were deposited," in contrast to an "old school of geologists" who placed "too much reliance upon lithic structure."

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[1] See discussion in Geol. Mag. for 1902, p. 554; 1903, pp. 36, 95, 141.

The present modes of dealing with geology are the outcome of a gradual growth from the foundations laid by William Smith in his "Strata identified by Organized Fossils"; the more detailed study of the succession of life-forms having been locally initiated by Strickland, and followed in ever-increasing detail. While the two schools may be said to be in active existence, there is no reason whatever for any antagonism between them. The "older" may be said to follow the broad outlines of Smith's grouping into stratigraphical divisions or formations, such as can be represented on geological maps; formations which indicate certain physical conditions, however local they may be, and the beginnings and endings of which must have varied considerably in point of time. None the less interesting are these formations and their fossils, their stratigraphical changes and method of origin; the part they play in the structure of the land, the relations of the rocks to the scenery and soils, and the economic applications of the strata. This aspect of geology is not one that collectively appeals very strongly to the author, the above matters being treated in a subordinate way when dealt with, and naturally enough. To work at the minute palæontological and chronological divisions demands not only special knowledge but prolonged and concentrated labour, otherwise the results can be of little value. The rocks, then considered rather as tombs for fossils, are not looked upon with the same affection as they are by those who are concerned mainly in tracing out the physical structure of a district.

The "new school," as it is called, is doing work on admirable lines. As Dr. Smith Woodward has remarked, "The variations of an organism in time and space, and its successive migrations, can only be ascertained by more detailed field-work and more precise labelling than has hitherto been customary among palæontologists"; indeed, "a most exact and exhaustive method of collecting" is necessary.[1] The work before us should therefore do much to stimulate further research on these lines in the Jurassic areas.

In considering this important task it is evident that to meet the requirements of both field-geologist and field-palæontologist two systems of geological nomenclature are requisite—the one dealing with formations, the other with epochs. In the new Guide to the Fossil Mammals and Birds (British Museum), lately noticed in the Geological Magazine, this is fully recognized, the author (Dr. Smith Woodward) observing, "It is just because rock-formations in different parts of the world so rarely are equivalent that a time-scale is needed to which each can be referred."

We should not omit to mention that the present author deals briefly with the scattered superficial deposits of the Cheltenham district, but these have not yet been mapped out in detail, and, as he truly remarks, their history "remains to be written." A fuller knowledge of the valley drifts will no doubt throw light on the popular subject of river-development. Meanwhile the subject has been ably handled by Mr. S. S. Buckman, and a summary of his views is given in one of the chapters, illustrated by a good physical map and by an effective view of meanders of the River Coln.

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[1] Proc. Geol. Assoc., vol. xviii, p. 429.

The volume is illustrated also by six photographic plates of fossils, mostly from the writer's collection, and among these only two ammonites are pictured: *Paltopleuroceras pseudocostatum* belonging to the "spinati hemera," and *Liparoceras capricornu* to the "capricornus hemera."

We may repeat, in conclusion, that to the seriously minded worker on the Cotteswold Hills this handbook will be a real help in indicating the present knowledge of the zonal palæontology of the district. Details of a great many pit-sections are given, accompanied by some capital photographic illustrations and sundry diagrams; there are illustrations also of the *Girvanella* and its connection with the little concretionary nodules of the Pea-Grit. The Appendices comprise a short list of minerals, copious lists of fossils, and an explanation of the geological map, reproduced from that of the Geological Survey, to which the author has made some additions.

H. B. W.

IV. — ORE DEPOSITS: A DISCUSSION. pp. 90. (New York: Engineering and Mining Journal, 1903. Price 5*s.* net.)

EARLY in 1903 two meetings of the Geological Society of Washington were devoted to a discussion on the genetic classification of ore deposits, in which several well-known geologists (S. F. Emmons, W. H. Weed, J. E. Spurr, W. Lindgren, J. F. Kemp, F. L. Ransome, T. A. Rickard, and C. R. Van Hise), who have done special work on ore deposits in connection with the United States Geological Survey, took part. The discussion was fully reported in the pages of the Engineering and Mining Journal, and, together with an introductory review, it is now reprinted in book form. An article by C. W. Purington entitled "Observations on Gold Deposits" is also reprinted as an appendix from the same journal.

A tentative classification, on which the discussion was based, was proposed by W. H. Weed, an outline of which is given below. Other classifications are proposed by Spurr and Van Hise. Although there are still considerable diversities of opinion, it is interesting to note that the theory of 'lateral secretion' finds little or no favour. For nearly all deposits of any importance an igneous origin, either directly or indirectly, is ascribed.

Genetic Classification of Ore Deposits.

I. Igneous (magmatic segregations).
    A. Siliceous (aplite and quartz-veins).
    B. Basic.

II. Igneous emanations. Deposits formed by gases above or near their critical point.
    A. Contact-metamorphic deposits.
    B. Veins (closely allied to magmatic veins and to division IV).

III. Fumarolic deposits. Metallic oxides, etc., in clefts in lavas.

IV. Gas-aqueous (pneumato-hydato-genetic) deposits. Igneous emanations or primitive water mingled with ground-waters.
  A. Filling deposits.
  B. Replacement deposits.

V. Meteoric waters (surface-derived).
  A. Underground.
  B. Surficial.

VI. Metamorphic deposits. Ores concentrated from older rocks by dynamo- and regional-metamorphism.

V.—MANUAL OF THE CHEMICAL ANALYSIS OF ROCKS. By HENRY S. WASHINGTON. pp. ix, 183. (New York, John Wiley & Sons; London, Chapman & Hall, 1904. Price 8*s.* 6*d.* net.)

THE object and scope of this work are well expressed by the first paragraph of the preface, which may, therefore, be quoted in full:—"The object of this book is to present to chemists, petrologists, mining engineers and others who have not made a particular study of quantitative analysis, a selection of methods for the chemical analysis of silicate rocks, and especially those of igneous origin. While the publication of such a work may seem superfluous in view of the existence of Hillebrand's treatise on this special topic, yet justification may be found in the fact that the latter is intended, not so much for one who is not very conversant with the subject, as for the practised analyst, to whom it is an indispensable guide."

With the exception of a few of the rarer chemical elements, the ground covered is the same as in Hillebrand's "Some Principles and Methods of Rock Analysis" (Bull. U.S. Geol. Surv., No. 176, 1900), which is the standard work on the subject. Fewer methods are, however, given, but these are described in greater detail so far as details of manipulation are concerned. A few figures of apparatus, such as are given by Hillebrand, would have added to the value of the book.

While, of course, it is of extreme importance to have analyses of rocks, yet it is still more important that these analyses should be accurate; and it is to be hoped that the apparent simplicity of the methods, as clearly stated in the book in such minute detail, will not lead to the multiplication of unreliable analyses by unskilled analysts.

VI.—DIE KRISTALLINEN SCHIEFER. I. Allgemeiner Teil. By Dr. U. GRUBENMANN. pp. 105, with 7 text-figures and 2 plates. (Berlin: Borntraeger, 1904. Price 3 M. 40 Pfg.)

THE author of this book, who is Professor of Mineralogy and Petrology in the University of Zurich, has for many years made a special study of the crystalline schists of the Alps, in which study he has been closely associated with Professors F. Becke and F. Berwerth, of Vienna. The present volume gives a general discussion of the subject, based on physico-chemical principles. A second volume is reserved for the description of the crystalline schists of special areas.

Commencing with a brief historical review and concluding with references to the literature, the subject-matter is divided under four main headings, as follows:—

A. The original material and its specific characters.
B. Metamorphism.
C. The products of metamorphism in their various forms.
D. The geological occurrence of crystalline schists.

VII.—THE ORBICULAR GABBRO AT DEHESA, SAN DIEGO CO., CALIFORNIA. By ANDREW C. LAWSON (Bull. Dept. Geol. Univ. California, vol. iii, 1904, pp. 383–396.)

A DESCRIPTION is given of the petrographical characters and field relations of an interesting type of gabbro from California. The normal type is a coarse-grained hornblende-gabbro with olivine and hypersthene, of which there are various local facies, one being the orbicular type. The spheroids, which were mistaken by the original finder of the rock for fossil corals, measure about six centimetres across. They consist of a core of felspar surrounded by concentric shells of radially crystallised olivine and basic felspar, the composition of the whole being that of a troctolite. Some suggestions are offered to explain the orbicular structure of igneous rocks, which though of somewhat rare occurrence is more common in acid than in basic rocks.

VIII.—YEAR-BOOK OF THE SCIENTIFIC AND LEARNED SOCIETIES OF GREAT BRITAIN AND IRELAND, ETC. 21st Annual Issue. 8vo. (London: C. Griffin & Co., 1904.)

IT is obvious that a book of reference of this nature, after appearing for twenty-one consecutive years, has filled a want. The Year-Book is thoroughly appreciated by some secretaries, as shown by the up-to-date information supplied. There are still others, however, who lag behind. Why, for instance, has the Secretary of the Geological Society of Glasgow not vouchsafed any details for two years? We also note that Mr. Monckton is still put down as President of the Geologists' Association of London, though succeeded by Dr. A. S. Woodward last February.

Messrs. Griffin & Co. would add a piece of useful information to each of the smaller local societies if they could obtain from the secretaries the last date on which a publication appeared. "Nothing since 1900" would be greatly appreciated by librarians, from whom such information is frequently sought.

REPORTS AND PROCEEDINGS.

GEOLOGICAL SOCIETY OF LONDON.

I.—December 21st, 1904.—J. E. Marr, Sc.D., F.R.S., President, in the Chair. The following communications were read:—

1. "On certain Genera and Species of Lytoceratidæ." By S. S. Buckman, F.G.S.

This paper deals with certain specimens sent by Mr. Beeby Thompson from the Northampton Sands, one of which is remarkable for its homœomorphy with *Phylloceras.* In order to classify the series of Toarcian–Aalenian Lytoceratidæ to which these species belong (*jurense* and allied groups), it is necessary to note that there is evidence of a definite sequence of phylogenetic stages. In ornament there is, at first, elaboration; but, later, simplification from a costate to a smooth stage. In whorl-shape there is a tendency to pass from the primitive evolute to the involute whorl, the umbilicus constantly contracting. Parallel with this there is a further tendency to pass from stout to more compressed whorls. While the Lytoceratidæ have a more primitive whorl-shape than the Phylloceratidæ, their lobe-line is more advanced; and hence, while the advance of the former produces a certain external homœomorphy with the latter, the more advanced lobe-line remains a feature of distinction. The successive stages of development may be indicated in terms of species, thus: (1) *Germaini,* (2) *torulosum,* (3) annulose species not yet named, (4) *jurense,* and (5) phylloceratoidan. Four new genera are described and two new species; three new names are proposed, and one generic name revised.

2. "The Leicester Earthquakes of August 4th, 1893, and June 21st, 1904." By Charles Davison, Sc.D., F.G.S.

The earthquake of 1893 was a twin, with its principal epicentre between Markfield and Woodhouse Eaves, and the other near Tugby, about 17 miles to E. 34° S. Its disturbed area contains about 2,200 square miles. In the north-western focus, the originating fault hades to the north-east, and is probably one of the group of faults on the north-east side of the Charnwood anticlinal axis, which appear to hade in the direction given. In the south-eastern focus, the fault hades in the opposite direction, the change of hade taking place a short distance to the south-east of Leicester.

On June 21st, 1904, two shocks were felt: the first a very slight one, at about 3.30 a.m.; the second at 5.28 a.m. The epicentre of the earlier shock was in the neighbourhood of Markfield and Groby, or near the south-eastern margin of the north-western focus of 1893. The second shock disturbed an area of about 1,200 square miles, and was a double shock, not a twin, for the foci were overlapping. It originated in a fault running nearly north-west and south-east, hading to the south-west, and passing a short distance from Tugby, and therefore in all probability coincident with the fault in action in 1893. The distance between the epicentres of the earthquakes of 1904 was about 12 miles. Thus, the foci of 1904 appear to have occupied the nearer margins of the foci of 1893.

3. "The Derby Earthquakes of July 3rd, 1904." By Charles Davison, Sc.D., F.G.S.

Although weaker than the earthquake of March 24th, 1903, this shock, owing to its occurrence at 3.21 on a Sunday afternoon, was felt over a much wider area (about 25,000 square miles). As in 1903, the earthquake was a twin, the epicentres being almost exactly coincident with those of that year, one being situated near Ashbourne, and the other, about 6 or 7 miles from it, near Wirksworth and Matlock Bath. The impulse at the south-western or Ashbourne focus was slightly stronger than the other, and took place a second or two later. The principal slip was preceded by a slighter one in the north-eastern focus at 2.28 p.m., and was followed, as in 1903, though after a short interval, by a slip in the interfocal region of the fault, at 11.8 p.m.

4. "Twin Earthquakes." By Charles Davison, Sc.D., F.G.S.

In a twin earthquake, the shock consists of two maxima of intensity, or of two distinct parts separated by a brief interval of rest and quiet. In Great Britain one in every twenty earthquakes is a twin, and our strongest shocks (the Colchester earthquake of 1884, the Hereford earthquake of 1896, etc.) belong to the same class.

The two parts of a twin earthquake differ in their order of intensity, both in different earthquakes and in different parts of the disturbed area of the same earthquake. The interval between the two parts varies on an average from 2 to 3½ seconds; and, although the twin shock is felt over a very wide area (sometimes over nearly the whole of the disturbed area), there may exist within it a band (the synkinetic band) in which the two parts coalesce and form a single shock.

These phenomena show that twin earthquakes cannot be caused by reflection or refraction of the earth-waves, nor by the separation of the waves of direct and transverse vibrations, nor by the repetition of the impulse within the same or an overlapping focus. They must therefore be due to impulses in two detached, or practically detached, foci; and it is shown that all the known phenomena of twin earthquakes can be thus accounted for.

In British twin earthquakes the distance between the epicentres varies from 4 to 23 miles, the average for seven recent earthquakes being between 10 and 11 miles. As a rule, the foci are elongated approximately in the direction of the line joining them, showing that they are portions of the same fault. The foci appear to be situated at different depths, and in two cases the fault probably changes hade in the region between them.

The existence of the synkinetic band and the brevity of the interval between the two parts of the shock show that, when the impulses are not absolutely simultaneous, the second takes place as a rule before the vibrations from the first focus have time to reach the other. Thus, twin earthquakes are due to a single generative effort; and they are caused, it is urged, by the growth of a crust-fold cut transversely by a fault. If the movement is such that the anticline of the fold is made more anticlinal and the syncline more synclinal, the middle limb will remain practically undisturbed; so that, by a single effort, there will be two impulses in detached foci situated at different depths. The average distance between successive anticlines and synclines in France along several lines lies between 9 and 12 miles, which agrees closely with the average distance between the epicentres of twin earthquakes.

II.—January 4th, 1905.—J. E. Marr, Sc.D., F.R.S., President, in the Chair. The following communications were read:—

1. "The Marine Beds in the Coal-measures of North Staffordshire." By John T. Stobbs, Esq., F.G.S. With Notes on their Palæontology by Wheelton Hind, M.D., B.S., F.R.C.S., F.G.S.

Owing to the disposition of the rocks and other causes, the stratigraphical position of the marine beds can be located with exactness *in situ*, and a large quantity of material can be obtained for examination. The horizons can be utilized for the identification of coal-seams and for the subdivision of the Coal-measures, as they are remarkably persistent, and can be frequently traced not only over the North Staffordshire field but in adjacent coalfields. The known horizons at which marine fossils have been obtained are the following, given in descending order:—

11. The roof of the Bay or Lady Coal.
10. The Priorsfield Ironstone Measures.
9. The Speedwell and Nettlebank Bed. } Below the Twist or
8. The Florence Colliery Band. } Gin Mine Coal.
7. Above the Moss Coal.
6. The roof of the Moss Cannel or Single 2-foot Coal.
5. Above the 7-foot Banbury Coal.
4. Beneath the 4-foot Coal of Cheadle.
3. The Knypersley Band.
2. Near the Crabtree Coal (three horizons).
And also 1. The Weston-Sprink Bed.

A map of the distribution of these beds is given, each one is described in detail, and a list of fossils found from the various exposures is tabulated. The Speedwell and Nettlebank Bed appears to be the most important marine bed in the coalfield; it is remarkably rich in species and individuals, and occurs in the upper portion of the true Coal-measures. Further, it proves the identity of the Twist coal of the Norton area with the Gin Mine of Longton. Lithologically, the marine beds are undistinguishable from the beds with which they are interstratified; but the fossils are usually in a good state of preservation and not confined to one particular bedding-plane; the individuals are likewise numerous. The marine mollusca are, however, sharply separated from the fresh-water forms, and no intermingling occurs. It is remarkable that several of the marine shales immediately succeed the coal-seams. A detailed table of the beds in North Staffordshire is

given, to show the exact position of the marine beds; and then several of the seams are traced into the Yorkshire, Lancashire, South Staffordshire, and Coalbrookdale fields. This tracing confirms the conclusion that the Hard Bed of Yorkshire is to be correlated with the Bullion coal of Lancashire and the Crabtree coal of North Staffordshire. Again, "Green's marine bed" at Ashton-under-Lyne coincides with the Gin Mine horizon of North Staffordshire; and this, again, with the Pennystone of South Staffordshire and Shropshire. Further, the marine beds indicate the approximate identity of the Silkstone, Arley Mine, and Cockshead seams. A bibliography is appended.

Dr. Hind, in his Notes on the Palæontology, remarks that from the base of the Pendleside Series to the top of the Coal-measures there is an unbroken succession of beds—at one time marine, at another estuarine, without unconformity. The two faunas—one with *Carbonicola*, *Anthracomya*, and *Naiadites*, the other with *Pterinopecten papyraceus* and Cephalopoda — occur in irregular alternations, the two faunas never mingling. The author proceeds to give notes on the occurrence of many of the species, and descriptions of some of them, including examples not hitherto known from Britain and one new to science. A table indicating the distribution of the species throughout the chief English coalfields concludes the paper.

2. "The Geology of Cyprus." By Charles Vincent Bellamy, M.Inst. C.E., F.G.S. With Contributions by Alfred John Jukes-Browne, B.A., F.G.S.

The following are the chief formations described:—

PLEISTOCENE.	Sandy limestones. Sands and conglomerates.	Up to 50 feet.
PLIOCENE.	Shelly limestones, with calcareous sands and sandstones.	100 to 150 feet.
Break.	Intrusion of igneous rocks.	
IDALIAN (OLIGOCENE).	White chalky limestones and marly chalks, with layers and nodules of flint.	About 1,000 feet.
	Grey and yellowish marls, with beds of gypsum.	400 feet.
KYTHRÆAN (UPPER EOCENE).	Grey felspathic sandstones and sandy shales.	? 1,500 feet.
Break.		
TRYPANIAN (? CRETACEOUS).	Grey limestones and dolomites; white and pink marbles, both massive and laminated.	Possibly 6,000 feet.

The Kyrenia Mountains form the northern rampart of the Central Plains, and they rise abruptly to heights of over 3,000 feet from the plain to the south and the sea to the north. They are composed of rocks tilted into a vertical position, much altered by compression and intrusion, and are devoid of fossils. They are referred by Professor Gaudry to the Cretaceous Period, and are compared by him with the Hippurite Limestones of Attica. They are pierced and marmorized by igneous rocks of quartz-felsite type. In some places they are schistose. Similar rocks are found in the extreme south-west of the island.

The Kythræan rocks attain a great development along the southern side of the Kyrenian Mountains. They are based on breccias and conglomerates made up of fragments of the Trypanian Limestones, and are thus probably unconformable. No fossils, except a few small tests of *Globigerina* and a few fragments possibly of shells, have been found in this series, which consists entirely of volcanic débris embedded in a calcitic matrix, like the 'Macignos' of Italy.

The Idalian Series appears to rest conformably on the last. The gypsum beds are largely developed in the south; the white chalky marls and limestones extend over nearly one-half of the island, and are always conspicuous from their intense whiteness. Foraminifera are abundant, and other fossils have been found which indicate that the beds are mainly of Oligocene age.

Igneous rocks are most conspicuous in the centre of the island, forming a mass of mountainous ground. They are intrusive into the formations already mentioned. The rocks include augite-syenite, rhyolite, liparite, olivine-dolerite, basalt, augitite, and several varieties of serpentine. Considerable metamorphism and much jasperization occur in association with them.

While most of the older sediments were formed in deep water, the fauna of the Neogene rocks is that of shallow-water deposits. Miocene rocks have only been recognized in the south-east of the island. The Pliocene strata lie in horizontal or slightly inclined beds, resting unconformably upon all older rocks. The Pleistocene rocks comprise: (1) Littoral limestones and pebble-beds, (2) soft shelly sands, (3) inland surface-conglomerates, (4) cave-earths, and (5) alluvial deposits. The cave-earths have yielded *Hippopotamus minutus* and *Elephas Cypriotes* to Miss D. M. Bate. An account of the chief economic mineral products of the island is given, including the marbles, clays, limestones, gypsum, building- and paving-stones, road-metals, metalliferous minerals, pozzuolana, terre-verte; and a note on the springs, salt lakes, and soils. Descriptions of some of the rocks, a note on the Miocene rocks, and a sketch of the physical history of the island are contributed by Mr. Jukes-Browne.

III.—January 18th, 1905.—J. E. Marr, Sc.D., F.R.S., President, in the Chair. The following communication was read:—

"On the Geology of Arenig Fawr and Moel Llyfnant." By William George Fearnsides, M.A., F.G.S.

This paper contains a detailed description of the succession of beds in Sedgwick's typical area of development of his Arenig Series. The following beds are described:—

Orthis limestone.
Thin ashy shales.
Upper ashes of Arenig and Llyfnant.
Dalfawr shales, with graptolites apparently of the *Didymograptus Murchisoni* zone.
Upper platy ashes, passing down into:—
Agglomerate.
Lower platy ashes.

Didymograptus bifidus beds: blue shales with ocasional ashes, passes down into:—
D. hirundo beds: dark calcareous shales, with some ashes.
Calymene ashes, with some calcareous material and occasional shaly beds.
D. balticus flags, quartzose flags with shaly partings.
Basal grit.
Unconformity.
Shumardia shales, passing down into:—
Asaphellus flags.
Bellerophon beds: hard shales, with *Parabolinella Salteri* in upper part.
Dictyonema band,
Niobe beds, } not well exposed.
Peltura beds, with *Niobe* and *Psilocephalus* near the top, and *Peltura* abundant in the middle part. These are separated by thin beds with *Orthis lenticularis* from:—
Parabolina beds, with *P. spinulosa.*

The unconformity marks the base of the Arenig Series. The *Orthis* limestone yields Lower Caradoc Sandstone forms, and dips beneath the great Black Shale Series, which occupies the adjoining belt of country.

The author discusses the relationship of these divisions to corresponding beds of other areas. He gives a description of the intrusive igneous rocks, and some account of the structure of the district and the nature of its glaciation.

CORRESPONDENCE.

CAVITIES IN CRYSTALLINE ROCKS.

Sir,—The cavities in the granite of Madagascar, described by the Rev. R. Baron in your January number, appear to be even more remarkable than those in Corsica and Portugal. But his explanation, though very ingenious, is, I think, attended by difficulties of its own. Between the ordinary drusy cavities and these large smooth hollows the gap seems wide and incompletely bridged by any of comparatively small size. Also, might we not expect that such hollows would sometimes be cut into by quarrying, and then have attracted notice? I cannot remember to have read of their occurrence, and have never met with anything of the kind, though I have been in several quarries, including the one mentioned at Ajaccio itself. Again, several of these hollows at that place occur rather as depressions on the surface of a block than as holes in it, and in positions unfavourable to the idea that any fairly thick slice has been removed from the rock in comparatively recent times. Of such the cavity represented on p. 390 of the Geol. Mag., August, 1904, may serve as an example, and I remember others in similar positions on the slope behind Ajaccio. Moreover, as the granite is generally in good preservation, showing, as Mr. Baron also remarks, only a little surface-decomposition, it must be weathering away slowly, and it is rather surprising to find the cavities retaining their superficial glaze. His description, however, seems to exclude the explanation of sand blast, and makes that of water corrosion still more difficult. But a serious objection to his own hypothesis has, I think, been overlooked. At least one of the cavities described by my friend Mr. Tuckett was not in granite but (as described by myself on p. 12 of last year's volume) in a rock which was more nearly allied to the pyroxenites and bore every appearance of having had the structure completely altered by pressure, which should have destroyed any pre-existent cavities. Thus, though deeming myself fortunate in having elicited such an interesting contribution to the discussion, I do not yet see my way to adopting his explanation of the difficulty. T. G. Bonney.

THE EASTERN GNEISSES OF THE SCOTTISH HIGHLANDS.

Sir,—Mr. G. Barrow's paper on the Moine Gneisses of the Highlands (Quart. Journ. Geol. Soc., November, 1904) revives memories of old controversies. In 1883 I gave reasons (Q.J.G.S., pp. 355–414) for believing that the thin-bedded gneisses east of the line of the great overthrust were older than the Assynt Series (now proved to be Cambrian), and I proposed to call them 'Caledonian.' Professor Lapworth's brilliant work on the dynamo-metamorphism of the Highland region quickly followed, and it suggested the possibility that the Eastern Gneiss was a *mélange* of rocks of different kinds and ages which had been rolled out in the earth-mill. However, the researches of the Geological Survey seem to have rehabilitated my original contention, since they lead to the conclusion that these gneisses, in the words of Dr. Horne, "represent sediments of siliceous and argillaceous type." Sir A. Geikie in 1891 proposed the name 'Dalradian' for the gneisses and associated rocks of the southern Highlands; but these are now correlated by the Survey with the Moine Gneisses of the north-west, that is, with my *Caledonian.* I held that these rocks were pre-Cambrian, but newer than the Hebridean; and this, I understand, is the view which Dr. Horne is disposed to adopt, when, in the debate on Mr. Barrow's paper, he points out resemblances between them and the pre-Torridonian schist north of Loch Maree. If therefore any name is to be given to these eastern gneisses, I respectfully submit that 'Caledonian' has priority over 'Dalradian.'

Mr. Barrow's memoir suggests another point. In my papers on the "Crystalline Rocks of Malvern" (1887–1893), I contend that black mica is produced from chlorite. This view was received with opposition. The peaceful pages of the Geological Magazine resounded with the weighty artillery of the late Lieut.-General McMahon thundering against "The Rape of the Chlorites." I declined to surrender, and now I am supported by Mr. Barrow, who remarks (p. 414) that "A striking feature of the grey gneisses is seen in the films of felted biotite, derived from original clastic chlorite . . . ." If chlorite is changed to biotite in Scotland, why not at Malvern, where too the associated acidic and basic rocks readily account for the necessary potash and iron-oxide? Since my heresy receives such respectable support it would seem to be worthy of reconsideration. C. Callaway.

Cheltenham.
December 27*th*, 1904.

THE DATE OF THE WORDS "ALTERED DEVONIAN" ON THE OLD GEOLOGICAL MAP OF SOUTH DEVON.

Sir,—Your reviewer has raised the interesting question as to the date when the words "Altered Devonian" were placed on the old Ordnance Survey Map of Devonshire of 1809.

As the Devonian system was only constituted in 1839 it must have been at or after that time. As De la Beche's Report was published in the same year all his work for the Report was completed before the term Devonian had come into use.

I venture to suggest the possibility that the term "Altered Devonian," whenever inserted, was not intended to apply to the metamorphic schist series but to the rocks immediately north of them, which, on the shores of Start Bay, are, I believe, universally admitted to be more or less altered. It seems impossible that De la Beche would ever have applied the term to the metamorphic schists further south, as he spared no opportunity to indicate his conviction that the latter were entirely distinct. De la Beche in his Report describes the different formations in successive chapters according to age. The schists are described in the chapter preceding that allotted to the grauwacke; and, in the epitome of contents, the superior antiquity of the schists is indicated without the shadow of doubt. A. R. Hunt.

January 14*th*, 1905.

GEOLOGY OF THE KINGSBRIDGE AND SALCOMBE DISTRICT.

Sir,—In a somewhat lengthy notice of the Geological Survey Memoir on the "Geology of the Country round Kingsbridge and Salcombe," which appeared in your last issue (January, 1905, pp. 26–37), on p. 32 we read: "The general strike of the green schist zone, where the two bands coalesce to form one, would seem to be approximately north-west and south-east. This direction is oblique to the general strike of the Devonians on the north, and, taken in conjunction with the fact that the eastern half of the Metamorphic boundary consists of green schists and the western half of mica-schists, seems to point to a considerable difference of orientation in the two systems. Yet the author fails to trace any evidence of pre-Devonian disturbance."

The general strike of the green schist zone here referred to merely applies to about a mile of country between the Moult and Marlborough (see pp. 38–39 of the Memoir), where the flattening out of the great mica-schist anticline of the Start in a series of minor folds allows the southern band of green schist to coalesce with the northern band which all along its range is conformable in strike to the general strike of the Devonian rocks. The green schists are thrown out along a series of small east and west folds on the west of the Salcombe estuary, and it is owing to this circumstance, and not to any difference of orientation, that mica-schists are in contact with Devonian on the west of the estuary. The maps bear out the above statements, and will show that the term band was not intended to mean a continuous outcrop.

Mr. Teall's description of the original character of the Metamorphic rocks and their likeness to Devonian sediments and igneous rocks associated therewith is a fact which deserves more consideration than the writer of the review seems inclined to give to it. As regards my own opinion as to the true boundary of Hope, that would depend on the acceptance of one view or the other, and to the age of the Metamorphic or metamorphosed rocks. Cogent facts are wanted, not opinions, and I am not prepared to enter any horse to win with. Certainly if I were I should not consider a plication of such magnitude as to repeat the Middle Devonian at Hope, a feat of legerdemain on the one side, or the repetition of similar conditions of deposit and of vulcanicity in the same area at widely different geological times, an impossibility on the other.

To be a strong partisan saves a good deal of troublesome investigation. Although no one can fail to see that the acceptance of an ancient series in the extreme south of Devon would be a convenient way of accounting for any extra disturbance in the Devonian rocks, the evidences of such, if present, are insufficient to afford material support to the pre-Devonian hypothesis.

W. A. E. Ussher.

'DEUTOZOIC.'

Sir,—When I used the word 'Deutozoic' I took it for granted that most of the readers of the Geological Magazine knew that the illustrious geologist who introduced the longer (and, etymologically, more correct) term 'Deuterozoic' had publicly sanctioned the employment of the word in its shortened form. J. G. Goodchild.

Royal Scottish Museum.
January 8th, 1905.

ON THE TERM 'DEUTEROZOIC.'

Sir,—The earliest work in which, to my knowledge, the word *Deuterozoic* is employed is Page & Lapworth's "Introductory Text-book of Geology," 12th edition, 1888, pp. 132, 133 (see also pp. 127, 129, 179, and 187 of same work). It includes the upper division of the Palæozoic, i.e. Old Red Sandstone, or Devonian, Carboniferous, and Permian. The lower division of the Palæozoic is termed *Proterozoic*, and comprises the Cambrian, Ordovician, and Silurian formations.

These terms *Proterozoic* and *Deuterozoic* do not seem to have taken hold, and have been neglected and forgotten except perhaps by Lapworth. I do not find any mention of them in any earlier geological work. In Lapworth's "Intermediate Text-book of Geology," 1899, he writes (p. 157):—

"By others [i.e. other geologists] the Palæozoic itself is divided in the same way as the Neozoic into two periods: (*a*) the *Protozoic* or *Preterozoic* (Gr. *protos*, first), including the Cambrian, Ordovician, and Silurian; and (*b*) the *Deutozoic* or *Deuterozoic* (Gr. *deuteros*, second), embracing the Devonian, Carboniferous, and Permian."

Curiously, however, in the late Professor Gümbel's "Grundzüge der Geologie," which came out in parts (and the full volume in 1888), on pp. 527–529 the transition series is placed in the following three subdivisions:—

I. Cambrische or Proterozen System (*Paradoxides* period).
II. Silur or Deuterozen System (Graptoliten period).
III. Devon or Tritozen System.

I think Gümbel's employment of these terms must have been published before the 12th edition of Page's Text-book, though Lapworth may not have seen them, and he has given an altogether different signification to his Proterozoic and Deuterozoic to what Gümbel has done. F.G.S.

OBITUARY.

HENRY PALIN GURNEY, M.A., HON. D.C.L., F.G.S., ETC.

BORN SEPTEMBER 7, 1847. DIED AUGUST 14, 1904.

HENRY PALIN GURNEY, eldest son of Henry Gurney and Eleanor Palin, was born in London on September 7th, 1847. He received his early education at the City of London School, proceeding afterwards to Clare College, Cambridge. There he distinguished himself both in Athletics and the Schools: he rowed in the college boat and ran for his university in the Oxford and Cambridge Sports of 1868 and 1869; he took both the Mathematical and Natural Science Triposes in the year 1870, being placed fourteenth wrangler in the former and in the first class in the latter; immediately afterwards he was elected to a college fellowship, which he held till 1883. In 1871 Mr. Gurney took orders in the Church of England, and for the next four years worked as curate to Canon Beck in one of the largest and poorest of London parishes, that of Rotherhithe; in the early part of that period he was married at Whitchurch, in Herefordshire, to Louisa, daughter of the Rev. H. Selby Hele, of Grays, Essex, and great-granddaughter of Bishop Horne.

Mr. Gurney's innate love of crystals had been developed under the influence of the Cambridge Professor, William Hallows Miller, during whose illness he later acted for some time as Deputy. Appreciating the difficulties which at that epoch presented themselves to English students, Mr. Gurney wrote a very simple and useful Manual of Crystallography (128 pages), founded on the Tract of Professor Miller and the Lectures of Professor Story-Maskelyne; it was published in 1875 by the Society for Promoting Christian

Knowledge. He was one of the Original Members of the Crystallological Society founded on June 14th, 1876, and was a member of its first Council. At one time he meditated acceptance of an appointment in the Mineral Department of the British Museum, but, notwithstanding the great attractions which work in a mineral collection would have had for him, he did not feel justified, having regard to the interests of his family, in becoming a candidate for a post of which the prospective emoluments must be both uncertain and small.

Instead, therefore, of making research in mineralogy and crystallography his lifework, Mr. Gurney accepted an offer made to him and became a colleague of, and afterwards (1877–94) managing partner with, Mr. Walter Wren in the large establishment which the latter had instituted at Westbourne Park for the training of candidates for the various competitive examinations for posts in the Army and in the Home and Indian Civil Services; there his vast energy, physical and mental, found full employment. His remarkable powers of organization, and the personal influence he was able to bring to bear on young men of ability at a very critical period of their lives, contributed largely to the success of the undertaking. The pupils of that establishment now occupy prominent posts in every part of Greater Britain, and it thus comes about that few tutors have ever been more widely known and respected. During a large part (1876–88) of this period, he officiated as curate of the church of St. Peter in Bayswater.

When the Principalship of the Durham College of Science, Newcastle-upon-Tyne, fell vacant through the resignation of Dr. William Garnett, it was felt that the educational experience, the wide culture and attainments, and the personal character of Mr. Gurney marked him out as the ideal man for that important position. His appointment to the post has been abundantly justified during the ten years which have since elapsed.

He devoted himself to the advancement of the interests of the college in every possible way. Of the thousands of students who have passed through the institution during his tenure of office, many will long remember his kindly advice and ready help. His charm of manner and sweetness of disposition made him everywhere popular; and at distributions of school prizes and public meetings in general in Newcastle and the surrounding district, he was sure of a hearty welcome. He took a leading part in inducing the promoters of the Armstrong Memorial Fund to devote its proceeds to the completion of the college buildings, and he afterwards gave help and encouragement in obtaining further subscriptions. Mr. Gurney provided a remarkable illustration of the well-known fact that the busiest man is the one who is most ready to add to his work and responsibilities; he was the representative of the college on the governing bodies of schools at Newcastle, Rothbury, Hartlepool, and Middlesbrough; he was a co-opted member of both the Newcastle and Northumberland Education Committees; he was *Chaplain* to the Bishop of Newcastle, and also to the Third

Volunteer Battalion of the Northumberland Fusiliers; he was Warden of the Newcastle Diocesan House of Mercy.

Notwithstanding the great multiplicity of the duties which fell to him as Principal, and the demands made on his time by the professorship of mathematics which he later combined therewith, Mr. Gurney found it possible to give some attention to the development of his old subject, the study of crystals. Impressed with the importance of crystallography both as an independent science and as auxiliary to chemistry, physics, mineralogy, and petrology, he equipped the college with apparatus for the measurement of the angles and for the determination of the symmetry and optical characters of crystals, and arranged that opportunity for the acquisition of a theoretical and practical knowledge of the science should be provided for Newcastle students.

Mr. Gurney received the honorary degree of D.C.L. from the University of Durham; he was a Fellow of the Geological and Physical Societies, and for several years was a member of the Council of the Mineralogical Society.

Whenever it was practicable for him, Mr. Gurney sought complete relaxation and change of thought in travel, spending many of his vacations abroad and availing himself of every opportunity of visiting places of general or geological interest both in Europe and America. With the present writer he spent several happy holidays; on one occasion journeying to Moscow, Nijni Novgorod, and down the Volga to Kazan, afterwards making an excursion with other members of the International Geological Congress to various noteworthy places in Finland; a brief account of the latter he gave in his "Notes on the Geology of Finland." He was an ideal companion; full of energy and enthusiasm; of infinite patience, good temper, and cheerfulness; indeed, to see his pleasant face and hear his hearty laugh was almost a holiday in itself. Only a few short weeks ago he proposed that they should again spend a few weeks together, this time at Arolla in Switzerland, where he was to go with two of his daughters, but the writer was unable to leave London. Soon afterwards came the startling news of his death. With only a walking-stick in his hand, he had started off alone at 8 a.m. on August 13th, not saying, probably not knowing, how far he was likely to go. Night came and he did not return. Search was immediately begun, and by dusk the next day his footmarks had been discovered on an *arête* of the Gysa, a southern spur of Mount Roussette; there they ceased. Soon after dawn on the following morning his body was discovered several hundred feet below; his watch had stopped at nearly 12. Notwithstanding the caution and carefulness which were ever prominent features in his own character, and were strongly impressed by him on others, he had doubtless been gradually led on by the beauty of the view to climb higher and higher, and had eventually and unexpectedly found himself in a place where a slip was easy and would mean instant death.

His loss will long be felt far and wide, more especially in the

North of England, where he had lived for the last ten years; but for the members of his family and his intimate friends, more especially for one to whom he always showed the kind feeling of a brother, it will cast a shadow over what remains of life.[1]

L. Fletcher.

ROBERT HARRIS VALPY, J.P., F.G.S.

Born September 16, 1819. Died December 18, 1904.

Mr. R. H. Valpy, whose death, in his 86th year, we regret to record, had been an active worker among the Devonian rocks of North Devon. Residing for portions of many years at Ilfracombe, he gathered together a rich collection of fossils from that neighbourhood, and his help was cordially acknowledged by Mr. Etheridge in the celebrated paper "On the Physical Structure of West Somerset and North Devon, and on the Palæontological Value of the Devonian Rocks" (Quart. Journ. Geol. Soc., vol. xxiii, 1867, see pp. 605–8, etc.). Mr. Valpy himself never published much, and his little work entitled "Notes on the Geology of Ilfracombe and the Neighbourhood" was issued anonymously, by Twiss & Sons, Ilfracombe. He was a man who seemed to shrink from publicity, and to prefer a quiet and retired country life. He was the only son of Capt. A. B. Valpy, R.N., of Combe Lodge, Blagdon, Somerset, and was born at Streatley in Berkshire. He was educated, first, under his relative, the eminent Dr. Richard Valpy, F.S.A., at the Reading Grammar School, and afterwards at Harrow and Balliol College, Oxford, and qualified in 1846 as J.P. for Berkshire. In 1849 he purchased the estate of Enborne Lodge, near Newbury, in Berkshire, and this was his principal home during the greater part of his life. There he was highly respected as "the good squire," and he lived to be the oldest magistrate in the county.[2]

When engaged in the re-survey of portions of the Mendip Hills in 1869 the present writer, together with Mr. Ussher, had the good fortune to meet Mr. Valpy at Blagdon. Every locality for fossils appeared familiar to Mr. Valpy, who pointed out the occurrence of trilobites in the basement portion of the Lower Limestone Shales near Burrington, the occurrence of bone-beds in the Carboniferous Limestone, and the presence of Rhætic beds in a somewhat abnormal position in the vicinity of Blagdon. He also mentioned that he had found striæ, which he considered might be of glacial origin, on blocks of Carboniferous Limestone in the Dolomitic Conglomerate. The information which he had acquired here, as elsewhere, by a very close study of the rocks, was ever generously placed at the service of others.

H. B. W.

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[1] Reprinted from the *Mineralogical Magazine*, October, 1904, vol. xiv, No. 63, pp. 61–64.

[2] If not the founder, he was a member of the Old "Valpeian Club," which dined together annually in London to keep alive the memory of old Dr. Valpy—the author of Valpy's Latin Grammar, on which so many boys were brought up!

THE
GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE V. VOL. II.

No. III.—MARCH, 1905.

ORIGINAL ARTICLES.

◆

I.—Sedgwick Museum Notes.

New Fossils from the Haverfordwest District. III.

By F. R. Cowper Reed, M.A., F.G.S.

(PLATE IV.)

Family HARPEDIDÆ.

Harpes sp. (Pl. IV, Fig. 1.)

In Mr. Turnbull's collection from the Sholeshook Limestone of the Sholeshook Railway Cutting there is a small but perfect 'horse-shoe' limb of a species of *Harpes*—a genus which has not been previously recorded from this bed. The 'horse-shoe' is oval and rather elongate, and narrow in proportion to its length; the arms curve inwards gently, so that their acutely pointed posterior extremities are approximate. There seems to be a marginal, single row of large pits round the outer edge of the flattened limb, but the general surface is covered with very minute punctæ. The inner edge of the limb is not well preserved. The arms extend backwards to about twice the length of the head-shield.

Dimensions.

	mm.
Width of horse-shoe	7
Length of ditto	11
Width of arms	3

Remarks.—This form has a more elongate horse-shoe, with the arms more curved inwards, than *H. Wegelini*, Angelin,[1] but this difference in shape may be more or less due to slight distortion in our specimen.

The genus is perhaps represented also in the Slade Beds.

Family TRINUCLEIDÆ.

Ampyx cf. rostratus, Sars. (Pl. IV, Fig. 2.)

It is not absolutely certain if the species *A. rostratus*, Sars,[2] really occurs in the British Isles, though it has frequently been quoted.

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[1] Schmidt: Rev. Ostbalt. Silur. Trilob., Abth. iv (1894), p. 69, t. v, figs. 10–18.

[2] Sars: in *Isis* (1835), p. 334, t. viii, figs. 3*a–c*.

The author has seen reasons for removing the Girvan trilobites previously referred to this species into another and new species;[1] but there is a specimen of a head-shield in Mr. Turnbull's collection from the Slade Beds of Upper Slade which bears a very close resemblance to the foreign form. The carination of the glabella is strong, and the cheeks only extend about half-way up its sides. The frontal spine, the relative proportions and shape of the various parts of the head-shield seem to be absolutely identical with what we know of *A. rostratus*. *A. tumidus*, Forbes, has been recorded by Messrs. Marr & Roberts[2] from the Sholeshook Limestone of the Haverfordwest district.

Family OLENIDÆ.

REMOPLEURIDES SALTERI, Reed, var. (Pl. IV, Fig. 3.)

Messrs. Marr & Roberts (op. cit., p. 481) recorded *Remopleurides radians*, Barr., from the Sholeshook Limestone.

There are examples of a species of this genus from the Slade Beds of the quarry at Upper Slade which cannot be referred to the same species, as they possess only two pairs of lateral furrows on the glabella, and the latter has a relatively much broader anterior tongue and is finely tuberculated round its posterior lateral margins. In these characters, as well as in its general shape and tuberculated neck-ring with serrated margin, it resembles *R. Salteri*, var. *girvanensis*, Reed,[3] and though the Slade specimens are too poorly preserved to identify them positively with this variety, yet I have no hesitation in ascribing it to the same species. The true *R. radians*, Barrande, is quite distinct, as I have verified by comparison with Bohemian examples of it.

Family PROETIDÆ.

CYPHASPIS MEGALOPS (McCoy).

This species was recorded by Messrs. Marr & Roberts[4] from the Sholeshook Limestone, but Mr. Turnbull has collected a good head-shield from the Slade Beds near St. Martin's Cemetery, Haverfordwest.

CYPHASPIS cf. HARKNESSI, Reed.

An imperfect head-shield, but showing the characters of the glabella clearly, was collected by Mr. H. Kynaston (now Director of the Transvaal Geological Survey) from the Slade Beds of West Pelcomb. It is comparable with the species described by the author[5] as *Cyphaspis* (?) *Harknessi* from the Keisley Limestone. The length of the glabella is about 8 mm., and its basal width is about the same.

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[1] Reed: Lower Palæozoic Trilobites of the Girvan District (Palæont. Soc.), pt. i (1903), p. 18.

[2] Marr & Roberts: Q.J.G.S., vol. xli (1885), p. 481.

[3] Reed: Lower Palæoz. Trilob. Girvan District, pt. i (1903), p. 39, pl. vi, figs. 8–15.

[4] Marr & Roberts: Q.J.G.S., vol. xli (1885), p. 481.

[5] Reed: Q.J.G.S., vol. lii (1896), p. 435, pl. xxi, fig. 2.

Family ACIDASPIDÆ.

ACIDASPIS (CERATOCEPHALA) TURNBULLI, sp. nov.

(Pl. IV, Figs. 4–7.)

There are several specimens in the Sedgwick Museum of a species of *Acidaspis* from the Sholeshook Limestone of the Haverfordwest district, which, though imperfect, afford sufficient evidence to recognise in them a new species. In one example the entire individual is preserved with the exception of about half the thorax and pygidium. The head-shield is not complete and is somewhat crushed, but with the aid of another specimen exhibiting some of the missing features more perfectly, a fairly full description can be given.

DESCRIPTION.—General form broadly ovate. Head-shield large, semicircular, moderately convex. Glabella oval or subcylindrical; median lobe convex, cylindrical, nearly parallel-sided, slightly expanded at front end so as to overhang the lateral lobes. Two pairs of lateral lobes present; the anterior pair small, elongate, obliquely oval; the posterior pair about twice the length of the anterior pair, narrow, elongate, pointed anteriorly, extending about half the length of the glabella. First lateral furrows strong, curving at first inwards and then running parallel backwards to the occipital furrows, thus completely separating median from lateral lobes of glabella. Second lateral furrows weak, oblique. Axial furrows arched gently outwards, increasing in depth posteriorly. Occipital furrow distinct, broad. Occipital ring broad, prominent, rounded, furnished with large median tubercle and pair of low, obscurely marked transverse occipital lobes; margin of ring provided with a pair of short, stout, subparallel spines. Fixed cheeks swollen, curved, elongated. Ocular ridge narrow, rounded. Surface of head-shield tuberculate, with a few scattered tubercles of larger size. (Pl. IV, Fig. 5.)

Thorax of nine segments; about 1½ times the length of head-shield. Axis narrow, strongly convex, prominent; axial rings furnished with distinct lateral nodular swellings. Pleuræ straight, horizontally extended at right angles to axis, each bearing a submedian broad elevated ridge with a narrow anterior border separated from it by a broad but shallow furrow, and a narrow posterior marginal band; ridge of pleuræ bears two prominent tubercles regularly placed at the same distance from the axis all down the thorax; extremities of pleuræ produced into two spines, an anterior short one and a posterior longer curved one with a tubercle at its base. (Fig. 6.) Pygidium (imperfectly known) broadly semicircular; axis (not well preserved) convex, prominent; lateral lobes flat, horizontally extended, with margin furnished with five or six pairs of long, slightly curved spines of equal size (the points are broken off in the specimen); surface of lateral lobes marked by three subparallel rounded pleural ridges, the middle one being the largest; the first ridge runs to the base of the third marginal spine, the middle one from the first axial ring to the base of the fourth, and the posterior and faintest one to the base of the fifth. (Fig. 7.)

DIMENSIONS.

	mm.
Length	29
Length of head	10
Length of thorax	14
Width of thorax	20

AFFINITIES.—The glabella of this species appears to bear a considerable resemblance to *A. callipareos*, Wyv. Thomson.[1] Double spines to the extremities of the pleuræ are found in the Bala species *A. Caractaci*, Salter,[2] and the pygidium is somewhat similar to this species, but the marginal spines are unequal in strength, and the head-shield is completely different. *A. evoluta*, Törnquist,[3] from the Leptæna Limestone, of which only the head-shield has been described, possesses a somewhat similar lobation of the glabella with a broad occipital ring and occipital lobes. *A. Jamesi*, Salter,[4] and *A. bispinosus*, McCoy,[5] two well-characterised British Ordovician forms, are quite distinct, save for the separation of the median lobe of the glabella and the pair of short occipital spines.

Note.—This new species appears also to be represented in the Slade Beds, from which Mr. Turnbull has recently obtained some specimens.

ACIDASPIS (CERATOCEPHALA) SLADENSIS, sp. nov.

(Pl. IV, Figs. 8–12.)

Another and smaller species of *Acidaspis* occurs in the Slade Beds; only the head-shield and the pygidium are known, but the specimens are nearly complete and in a good state of preservation.

DESCRIPTION. — Head-shield semicircular, moderately convex. Glabella oval, nearly as wide as long; median lobe convex, cylindrical, fairly well marked off from the lateral lobes, expanded a little in front, gently rounded or subtruncate anteriorly. Anterior pair of lateral lobes oval, convex, less than one-third the length of glabella; posterior pair oval, convex, nearly twice as large as anterior pair, not strongly marked off from them. First pair of lateral furrows short, curved back to meet second pair; second pair weak between lateral lobes, but continued backwards more strongly along inner side of second lateral lobes to enter occipital furrow. Occipital furrow strong, wide, horizontal; occipital ring broad, nearly one-third the length of glabella, provided with large median tubercle and obscure traces of small occipital lobes; margin furnished laterally with pair of posteriorly directed divergent long spines. Axial furrows distinct, arched outwards. Fixed cheeks swollen, curved, widening posteriorly to nearly the width of glabella. Ocular ridge narrow, raised, rounded. Eyes small, situated wide apart, and far

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[1] Wyville Thomson: Q.J.G.S., vol. xiii (1857), p. 208, pl. vi, figs. 11, 12.
[2] Salter: ibid., p. 211, pl. vi, figs. 15–17.
[3] Törnquist: Undersokn. Siljans. Trilobitf. (1884), p. 28, t. i, fig. 24.
[4] Salter: Mem. Geol. Surv., dec. vii (1853), pl. vi, figs. 1, 2, 3.
[5] Salter: ibid., p. 4, pl. vi, fig. 4.

back, nearly opposite middle of posterior lateral lobes. Neck segment rounded, narrow, widening laterally, marked off from fixed cheeks by strong furrow. Facial sutures cut posterior margin of head-shield far out. Anterior margin of head-shield provided with narrow raised rounded border with strong marginal furrow. Surface of head-shield coarsely tuberculated. Thorax unknown.

Pygidium broadly semicircular, transversely expanded, almost flat; posterior margin furnished with seven pairs of equidistant short radiating spines of equal length and size. Axis convex, short, bluntly terminating inside narrow raised rim, not quite one-third the width of the pygidium, composed of two segments and of a small articulating ring in front; first segment formed by a complete rounded ring; second segment broader and bearing a median pair of large tubercles and a lateral pair of smaller ones. Lateral lobes flat, horizontally extended without definite pleural ridges, but with 2–3 large elongated tubercles. Marginal rim raised, rounded, narrow, with regular double row of tubercles. Marginal spines granulated. (Pl. IV, Figs. 11, 12.)

DIMENSIONS.

	mm.
Length of head-shield	3·0
Length of pygidium (without spines)	1·5
Width of ditto	4·0

AFFINITIES.—This species has many of the characters of *A. Lalage*, Wyv. Thomson,[1] particularly in the lobation of the glabella and occipital spines, but it differs in the coarse tuberculation of the head-shield and in the features of the pygidium. The pygidium, indeed, more resembles that of *A. hystrix*, Wyv. Thomson,[2] but the latter has distinct pleural ridges on the lateral lobes, and no pair of conspicuous tubercles on the second axial segment. *A. Grayæ*, Etheridge,[3] is too imperfectly known, but the pygidium is certainly distinct.

Both these species, *A. sladensis* and *A. Turnbulli*, belong to the subgenus *Ceratocephala*, Warder, 1838 (type *C. goniata*, Warder), as understood and limited by Clarke.[4] Van Ingen[5] suggests using the divisional names *Odontopleura*, *Selenopeltis*, *Ceratocephala*, *Dicranurus*, *Acidaspis*, and *Ancyropyge* in a generic sense, but this does not seem desirable, as the value of these groups is scarcely of so high a rank.

Family LICHADIDÆ.

LICHAS (METOPOLICHAS) AFFINIS, Angelin, var.

(Pl. IV, Fig. 13.)

There is one fairly well-preserved pygidium of a species of *Lichas* from the Slade Beds which cannot be referred to any common British species. In shape it is broadly parabolic; the axis is conical, convex, about one-third the width of the pygidium in front, is not enclosed by a furrow behind, but sinks down rather suddenly to the general level of the lateral lobes in the postaxial piece; there are three distinct narrow rings on the front part of the axis, followed by lateral traces of a fourth; the posterior end of the axis is elevated into a blunt tubercle. The axial furrows converge posteriorly to a little behind the axis and then curve gently outwards. The lateral lobes are flat, horizontally extended, and consist of three pairs of pleuræ, each well-defined and traversed by a diagonal furrow of equal strength, but only the first two pairs of pleuræ end in free points beyond the margin, the third pair not interrupting the regular rounded outline of the posterior edge of the pygidium. The free ends of the second pair, which are alone preserved in our specimen, project as short, broad, slightly recurved points. The postaxial piece, which is broad, appears not to be marked off posteriorly from the third pair of pleuræ, the limiting furrows dying out before reaching the margin. The surface of the pygidium is uniformly tuberculated. There is a wide concentrically striated fascia on the inferior surface, extending inwards nearly to the tip of the axis.

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[1] Nicholson & Etheridge: Mon. Foss. Girvan, fasc. i (1878), p. 121, pl. viii, figs. 20–22 (*non* figs. 17–19).

[2] Ibid., p. 123, pl. viii, fig. 25.

[3] Ibid., p. 126, pl. viii, fig. 26; pl. ix, figs. 1–7.

[4] Clarke: Tenth Report New York State Geol. (1891), p. 67, pl. i, fig. 1.

[5] Van Ingen: School of Mines Quarterly, vol. xxiii (Nov. 1901), No. 1, pp. 36–39.

DIMENSIONS.

	mm.
Length	14
Width ... ... (about)	18

AFFINITIES.—The figure given by Schmidt[1] of a pygidium which he attributes to *L. depressus*, Angelin,[2] resembles this specimen in general characters, and particularly in its rounded posterior outline and in the short free points of the two first pairs of pleuræ, the third pair ending within the margin. But the axis is not of the same shape, and has only two rings on it. Schmidt also states that he is doubtful about the characters of the posterior portion, and it may not have a rounded outline behind the second pleuræ. Angelin's figure certainly does not convey the same impression. But *L. affinis*, Ang.,[3] and *L. conformis*, Ang.,[4] in spite of being more pointed behind, are undoubtedly the nearest allies, the shape of the axis, number of segments, posterior tubercle, lateral lobes, pleuræ and furrows agreeing much more closely than any others; and without any hesitation I assign this Slade form to this group which has been called *Metopolichas*.[5] A form from the Keisley Limestone has been referred by the present author[6] to *L. affinis* on the strength of some pygidia and a head-shield, and another to a variety of *L. conformis*.

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[1] Schmidt: Rev. Ostbalt. Silur. Trilob., pt. ii (1885), p. 95, pl. iv, fig. 4.

[2] Angelin: Pal. Scand. (1854), p. 70, pl. xxxvi, fig. 4*a*.

[3] Ibid., pl. xxxviii, fig. 4*b*.

[4] Ibid., pl. xxxviii, fig. 5.

[5] Reed: Q.J.G.S., vol. lviii (1902), p. 73.

[6] *Reed:* Q.J.G.S., vol. lii (1896), p. 427.

LICHAS (METOPOLICHAS) LACINIATUS, Dalman (?).

There is one specimen of a pygidium probably referable to this species from the Slade Beds exposed at the roadside a few hundred yards west of St. Martin's Cemetery, Haverfordwest, in Mr. Turnbull's collection. Though this specimen is not well preserved, the more elongated form distinguishes it from *L. affinis*. *L. laciniatus* has been described from the Bala of the Lake District[1] and other British localities.

LICHAS (PLATYLICHAS) MARGARITIFER, Nieszkowski, var.

Some fragments of head-shields of a species of *Lichas* were collected by Messrs. Marr & Roberts from the Slade Beds of Robeston Wathen and Ben Lomond Cottage, Haverfordwest, but no specific identification was given. Portions with similar characters from the same horizon occur in Mr. Turnbull's collection. They must undoubtedly be referred to that section of the genus which has been designated *Platylichas*,[2] and they are almost indistinguishable from *L. margaritifer*, Nieszk.,[3] of the Baltic provinces, to which a form from the Chair of Kildare Limestone has also been referred. The median lobe of the glabella and the bicomposite lateral lobes have the typical shape and definition of this species; the axial furrows are likewise quite obsolete posteriorly, the fixed cheeks and the fourth lateral lobes being completely fused and forming a gently convex surface, marked off from the median lobe by the additional furrow which connects the base of the bicomposite lobes with the occipital furrow; there is the usual pair of small rhomboidal occipital lobes; and the eye-lobe and furrow are well seen. The surface seems to be finely tuberculated rather than granulated; and there is a median tubercle on the neck-ring in one of the specimens, which is apparently absent in the Russian examples.

Family CHEIRURIDÆ.

CHEIRURUS (s.g. PSEUDOSPHÆREXOCHUS) aff. SUBQUADRATUS, Reed.

The subgenus *Pseudosphærexochus* has been recorded by the author[4] from the Keisley Limestone, and its relations have been discussed in another place.[5] Its presence in the Haverfordwest area has now to be recorded, specimens of head-shields showing the typical features, but not well enough preserved for precise specific identification, occurring in the Slade Beds of Upper Slade in Mr. Turnbull's collection. The form appears to resemble *Ps. subquadratus* of the Keisley Limestone very closely.

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[1] McCoy: Synops. Brit. Pal. Foss. Woodw. Mus., p. 150, pl. 1 F, fig. 17 (*L. subpropinqua*).

[2] Reed: Q.J.G.S., vol. lviii (1902), p. 72.

[3] Nieszkowski, Mon. Trilob. Ostseeprov.: Archiv. Liv.-Est-Kurland, ser. I (1857), p. 568, t. i, fig. 15.

[4] Reed: Q.J.G.S., vol. lii (1896), p. 421, pl. xx, figs. 10, 11.

[5] Reed: GEOL. MAG., Dec. IV, Vol. III (1896), pp. 117, 161.

EXPLANATION OF PLATE IV.

FIG. 1. *Harpes* sp. 'Horse-shoe' limb. Sholeshook Limestone. × 3.
,, 2. *Ampyx* cf. *rostratus*, Sars. Head-shield. Slade Beds, Upper Slade. × 2½.
,, 3. *Remopleurides Salteri*, Reed, var. *girvanensis*. Slade Beds, Upper Slade. × 2½.
,, 4. *Acidaspis Turnbulli*, sp. nov. Nearly entire specimen, with the exception of half the thorax and pygidium. Sholeshook Limestone, Haverfordwest. × 2.
,, 5. ——— Outline figure of restored head-shield.
,, 6. ——— Restored outline of one of the thoracic segments.
,, 7. ——— Restored outline figure of pygidium.
,, 8. *Acidaspis sladensis*, sp. nov. Head-shield, showing the glabella; the cheeks imperfect. Slade Beds. × 5.
,, 9. ——— Head-shield of a larger individual. × 5.
,, 10. ——— Restored outline of head-shield.
,, 11. ——— Pygidium. × 5.
,, 12. ——— Outline of pygidium restored.
,, 13. *Lichas affinis*, Angelin, var. Pygidium. Slade Beds, Haverfordwest. × 2.

II.—Some Notes on the Gold Occurrences on Lightning Creek, B.C.

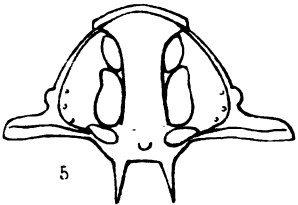
By Austin J. R. Atkin, Esq.

LIGHTNING CREEK occupies a wide valley in a weakened zone in the series of rocks known as the Cariboo schists. It has been stated by Mr. Bowman (Canadian Geological Survey, 1885 and 1886), and confirmed by later observations, that the centre of the deepest known erosion follows very closely the anticlinal axis in these schists. The occurrence of the very rich spots for which this stream is justly famous, both below its present level and at points many feet above it, have long been a source of discussion amongst the miners who worked here. It is hoped these notes gathered during three years studying this difficult problem may be of assistance to future observers, and perhaps lead to the discovery of rich benches in hitherto unsuspected places.

There have been four distinct channels followed by this stream, all of Tertiary age. The oldest or Devil's Lake stream (see map) emptied into a different river from the present creek, and is about 600 feet[1] above the channel of the latest Pliocene stream, at present buried under from 50 to 150 feet of drift of Glacial and Pleistocene age. Between this and the latest Pliocene channel are the Butcher and Dunbar Flat Benches, both the sole known remains of a stream which once ran at this level.

Below these, and only about 20 feet above the deepest channel yet discovered, is the bench belonging to the Point Mining Company, which I have called Fry's Bench. This bench, being more silicified than the rest of the slates, resisted erosion while the stream cut down on the outside. The gravel and gold occurrence was studied here, the other channels being worked out in the early seventies. This small patch—the best of it being only 80 feet long by 10 feet wide—was very remarkable for its richness, an area of 35 square feet having produced as much as 260 ounces of gold. In some

[1] All levels taken by aneroid, both for paper and map.



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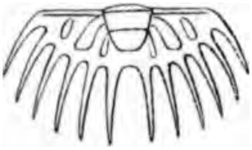

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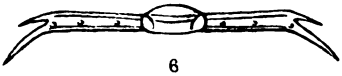

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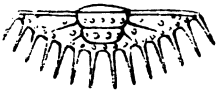

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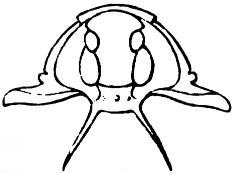

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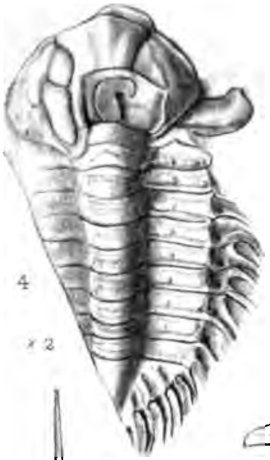
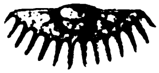


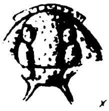
4

× 2



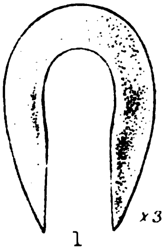
× 5

11



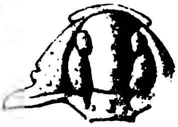
× 5

8



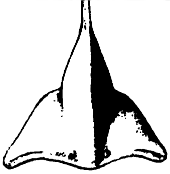
× 3

1



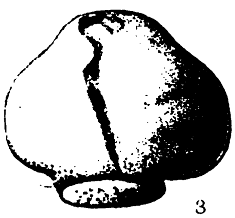
× 5

9



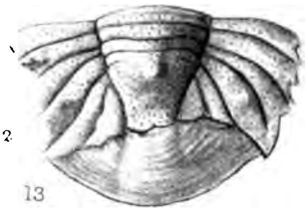
× 2½

2



× 2½

3



× 2

13

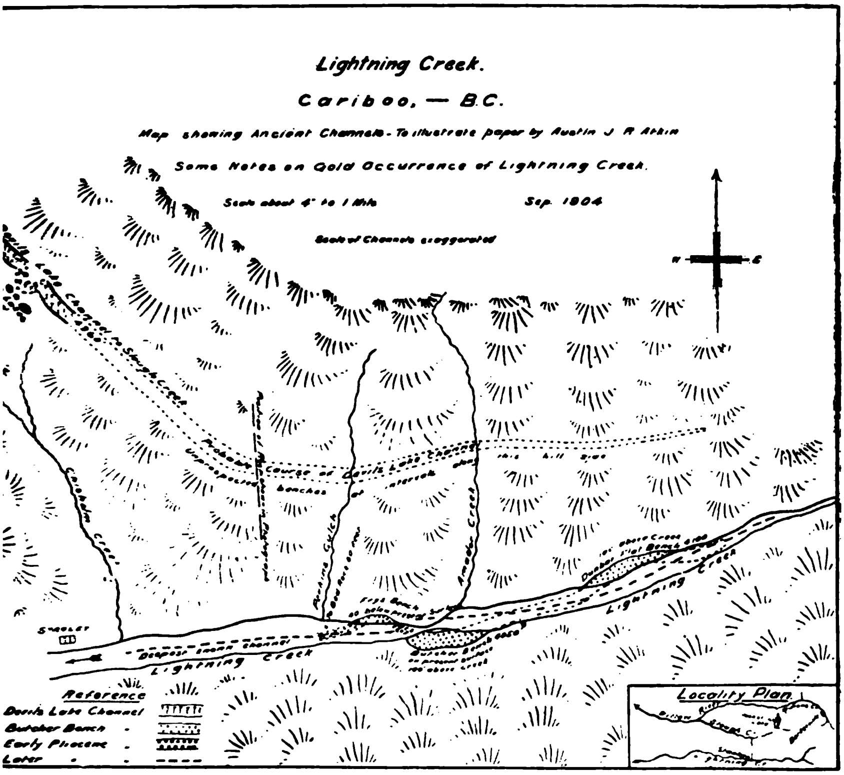
G. M. Woodward del. et lith. West, Newman imp.

Trilobites from Haverfordwest.

places the gold was so plentiful that the writer has picked up 15 ounces in a few minutes from the crevices in the broken bed-rock. The reason for this striking richness was shown in the patch occupying a pool at the foot of a fall in the old stream.

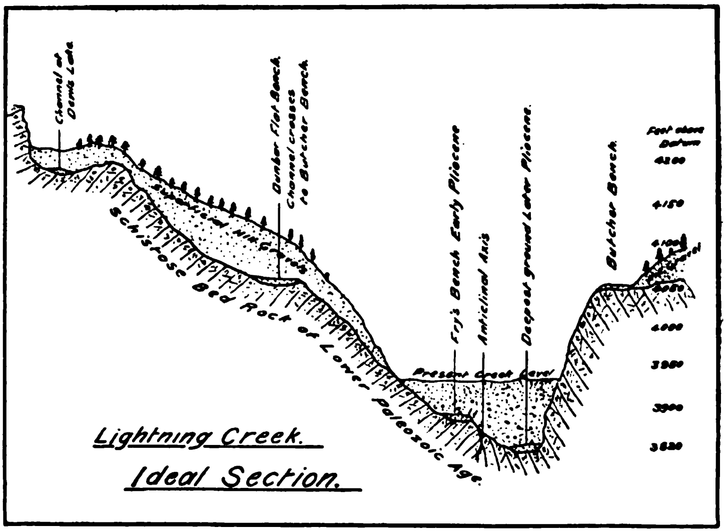
All the gold was very water-worn and large, the smallest piece being about 10 grains in weight, and was in the crevices of the rock, together with hydrated oxide of iron, which was doubtless the pyrites of that age.

The benches known as Butcher Bench and Dunbar Flat were the same stream of a still earlier date, and produced several of the largest pieces of gold found in the country. Some of the nuggets weighed over 30 ounces, but contained a little quartz and were rougher in appearance than those found in the deeper channels. It was the erosion of this channel that enriched the Point Bench and the deeper ground to the left. Most of the quartz probably got washed out of and separated from the rest of the gold on its travel down to the deeper levels.



The most interesting of all the channels of this valley is the oldest or Devil's Lake channel. Emptying as it did into the valley of Slough Creek, *it represents* a period when the drainage was very much higher than at present, and may possibly be as old as Miocene. It is the only channel so far discovered in the country of this period, and I have no hesitation in attributing the gold deposits of Lightning Creek to the erosion of this old channel, which also produced the rich benches along Slough Creek (see locality plan) when the watershed drained into Willow River instead of into Cottonwood River as it does at present. The enormous extent of the erosion can be judged when the deepest gutter below the present creek at Stanley is 600 feet lower than the benches above Devil's Lake, which are the only discovered remains of this old channel within the present drainage area of Lightning Creek.

While very little gold remains in Amador Creek, the sudden failure of the auriferous lead on Perkins Gulch appears to indicate the probable level at which this channel ran; there is nothing more suggestive than the rock prominence shown in the photograph.[1] This cliff probably marks a point around which the oldest channel once ran, confined on the outside by the rock prominence. The terraces further along the hill may be Post-Glacial débris resting on the benches of this stream, or the result of the receding waters of Pleistocene times terracing the loose deposits.



Lightning Creek.
Ideal Section.

Summing up these notes, I look on the richness of the Pliocene channel of Lightning Creek as due to the concentration of the gold contained in the beds of the stream when it ran at the level of Fry's Bench; and on Butcher Bench and Dunbar Flat level at a still earlier date. This last in turn owes its richness to the earliest channel, the course of which I have tried to indicate.

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[1] The Editor regrets that the photograph referred to by the author was too small and not sufficiently clear for reproduction by process.

III.—Some Transvaal Eruptives.

By R. F. Rand, M.D., F.L.S.

THE following petrographical notes refer to examples of igneous rocks collected by the writer during a visit to the Transvaal in the Summer of 1904. Thin sections of the rocks have since been made, and it was thought the following condensed accounts of their appearances might perhaps prove a useful record.

Meg. is prefixed where megascopic characters are noted; *Mic.* where the allusion is to microscopic features. The magnification, unless otherwise stated, is one of 60 diameters.

Nos. 1, 2, 3, 4, 5, and 6 are examples of the granite which emerges two miles or so due north of the Johannesburg P.O. (the point to which distances in the Johannesburg district are referred). The Witwatersrand Series of clastic rocks, the gold-bearers, dip away towards the south, their northern edge forming a bold escarpment overlooking the granite. The specimens, collected from different points, have a general likeness and are grey in colour.

No. 1.—Locality: small quarry close to the Hyde Park Estate, 5¼ miles north of Johannesburg.

Meg. A medium-grained type. Sp. gr. 2·62.

Mic. Shows the usual granitic type of structure. Quartz bulks largely; it is traversed by strings and bands of minute bubbles, and includes many fine straight needles, some of which are nearly a millimetre in length. They are probably rutile. The felspars are microcline, plagioclase, and orthoclase in about equal proportions. All show alteration, but the microcline is in, by far, the freshest condition. The change is principally one of kaolinization, but amid the cloudiness many fine flakes of muscovite are recognisable. The soda-lime felspar is oligoclase, it shows fine albite twinning, and has a mean refractive index slightly lower than that of the adjoining quartz. The orthoclase is in Carlsbad twins and shows zonary decomposition.

The ferro-magnesian elements are biotite and hornblende in about equal quantities. The biotite is intensely pleochroic, and encloses sphene, sometimes in crystals, but more often in grains. The hornblende is bottle-green in colour, and usually lies in association with the biotite. It frequently encloses epidote, both as crystals and grains. Apatite occurs sparingly, sometimes enclosed in the biotite. A few small zircons are to be seen. Here and there are small patches of a micrographic intergrowth of quartz and felspar, the felspar dominant and quite turbid.

No. 2.—A fine-grained example from the same quarry as No. 1. Sp. gr. 2·59.

Mic. The minerals are the same as in No. 1, but the grains are smaller. The difference between the refractive indices of the quartz and the felspars gives the surface of the section a curiously uneven semblance, the quartz appearing to lie at the bottom of shallow hollows. The biotite shows inclusions of sagenitic rutile.

No. 3. — Locality: Waverley Estate, 5½ miles N.N.E. of Johannesburg.

Meg. A medium-grained type. Sp. gr. 2·66.

Mic. The quartz is of the usual kind, but there is an absence of the rutile needles noted in No. 1. The felspars are microcline, orthoclase, and plagioclase, as before. Hornblende is present, but no biotite. It is pale green in colour, and carries, as inclusions, granules of sphene, small crystals of magnetite, and a little apatite.

Accessories.—(*a*) Sphene, in good crystals of a yellowish-brown colour and carrying numerous magnetite crystals as inclusions. The sphene crystals are sometimes a millimetre in length, so that with a little scrutiny they may be made out in the hand-specimen. (*b*) Pyrites, in crystal-groups and sometimes in grains, sporadic in its distribution. (*c*) Apatite, in fairly large crystals.

Muscovite, calcite, and epidote all occur sparingly, as decomposition-products. Micrographic intergrowth of quartz and felspar is present, but in less degree than in No. 1.

No. 4.—Locality: Norwood, 4 miles north-east of Johannesburg and about ¾ mile from the escarpment of the Witwatersrand Series.

Meg. Of rather coarser grain than that of the preceding numbers. Sp. gr. 2·66.

Mic. Shows quartz as in No. 1. The felspars are the same, the orthoclase showing very good zoning. Hornblende and biotite occur, the former preponderating. Mixed up with the hornblende, at whose expense it appears to have grown, is a large quantity of epidote, sometimes showing good crystal outlines. Sphene occurs in good crystals, which occasionally show excellent cleavage-cracks. It is sometimes enclosed among the hornblende-clusters. Apatite as in previous examples.

No. 5.—Locality: a small quarry near stream which escapes towards the granite below Sans Souci. About 2½ miles N.N.W. of Johannesburg and close to the Witwatersrand Series escarpment.

Meg. The rock is of medium grain, its minerals tending towards directional arrangement. Sp. gr. 2·76.

Mic. The quartz is in smaller grains. It appears to have suffered some comminution. The felspar is striped, much decomposed, and largely predominates over the quartz. The hornblende is in large individuals, of greenish colour and irregular outline; the coloration is patchy, and the interior of the crystal often shows bleaching. Pleochroism is strong, yellow to indigo-blue. Sphene, epidote, and apatite are commonly enclosed within the hornblende-groups, the epidote abundantly. A few zircons are noticeable.

No. 6.—Aplitic vein from the same quarry as No. 5.

Meg. Milk-white in colour and holocrystalline. Sp. gr. 2·62.

Mic. Consists almost exclusively of quartz and felspar. Quite rarely a little epidote is to be seen, decomposed at core into calcite; a shred or two of hornblende; and small stray crystals of pyrites. Between crossed nicols one sees a pell-mell of quartz and felspathic fragments, the quartz often in large irregular grains, and, grouped around them, are smaller fragments of plagioclase, mostly with their long axes in rude parallelism. In certain cases the felspar has undergone extreme destruction and is reduced to a granular mosaic. Of the larger plagioclase fragments, some are bent, some are broken. The microcline appears to be of tougher nature than the plagioclase, having survived in larger fragments; these show a vague, undulatory extinction.

Nos. 7, 8, and 9 present some resemblances among themselves sufficient to warrant their being grouped together.

No. 7.—Locality: near by the spur of the Witwatersrand Series, around which the stream winds in its escape northwards out of the Bezuidenhout Valley. From bed of stream. The rock occupies an intermediate position between the granite and the eruptive which occupies the floor of the Bezuidenhout Valley, a rock which is referred to later on.

Meg. A close-grained, holocrystalline rock, of dark bluish-grey colour. Sp. gr. 2·96.

Mic. The prevailing elements are rhombic pyroxene and amphibole, the two often intergrown. The hornblende is very pale, and appears to be largely derived from the bronzite, of whose crystals it often constitutes the core. The bronzite is in large columns with brush-like endings. Much of it has undergone the usual bastitic alteration. Isolated crystals of hornblende occur, showing good prismatic cleavages. Amidst the foregoing lies greatly decomposed plagioclase with broad albite lamellæ, and having epidote as its chief decomposition-product. There is also a little quartz and a micrographic intergrowth of quartz with felspar. Chlorite is present in a few stray patches. Pyrites occurs in fair quantity. Opaque patches of reddish tinge may be stained leucoxene, which is apparently passing over into sphene. It may denote a pre-existent ilmenite, and sometimes lies in association with the pyrites.

No. 8.—Locality: irregular mass intrusive in the Witwatersrand Series near Sans Souci. A few hundred yards distant from the granite.

Meg. A fine-grained rock, holocrystalline. Colour dark-bluish black and light grey, in fine mottling. The weathered surface is rusty. Sp. gr. 2·91.

Mic. The most abundant constituent is hornblende, pale in colour, sometimes twinned, oftentimes fibrous. It interlaces with a greatly decomposed columnar plagioclase. In the meshes lies a micrographic intergrowth of quartz and turbid felspar. A clear plagioclase, referable to labradorite, is present in quite subordinate quantity. Ilmenite is present, mostly decomposed into leucoxene, and here and there are a few specks of pyrites.

No. 9.—Locality: from a dyke traversing the granite in Bramley township, 6 miles N.N.E. of Johannesburg. The dyke trends north and south.

Meg. Much resembles No. 8 in appearance, but is slightly darker in colour. Sp. gr. 2·99.

Mic. The appearance is ophitic. The meshes of the striped felspar are occupied by serpentine, apparently derived from hornblende, of which some unaltered fragments remain. The hornblende itself is probably largely secondary. The serpentine is frequently bordered with a hem of chlorite, with pleochroism green to blue. Quartz is present in fair quantity. Plates of ilmenite are abundant, decomposed for the most part into leucoxene. A few crystals of apatite occur.

Klipriversberg Amygdaloid.

Nos. 10 and 11 illustrate this rock, which overlies the Witwatersrand Series some 5 miles south of Johannesburg, where it forms a range of rugged hills. In places it shows a characteristically amygdaloidal structure, which is brought out very clearly by weathering, the resistant quartz amygdules standing out in bold relief.

No. 10.—Locality: northern fringe of Klipriversberg Range by Meyer's Farm, 5 miles south of Johannesburg.

Meg. A dark bluish-grey rock of dull, fine-grained texture, the ground carrying a few glassy, tabular crystals of felspars showing albite striation. Darker spots represent the amygdules, which, in the specimen under review, are small. Sp. gr. 2·83.

Mic. The ground-mass is made up of a mass of felspathic microlites, mostly showing the parallelism indicative of flow. Amidst the microlites is a good deal of granular opaque matter, which is white by reflected light. The microlites are long and slender, and, as they extinguish almost parallel with their length, are probably oligoclase. Some of larger growth are striped. Lying among the felspathic microlites of the ground-mass are numerous fine needles of amphibole, which appear to grow at the expense of the opaque matter noted above, increasing in number as the opacity clears up.

The large felspar phenocrysts are few in number, are much decomposed, and show albite twinning. The ferro-magnesian element of the first generation is represented by pseudomorphs of pale-greenish chloritic matter, granular in appearance, faintly pleochroic, and ranging between crossed nicols from an intensely deep blue to complete isotropism. These pseudomorphs perhaps succeed olivine. They frequently enclose epidote in good crystals.

The amygdular cavities show varying contents. They are commonly filled in part by a material very similar to that of the pseudomorphs, but which in the amygdular cavities passes over into, what is doubtless to be regarded as, isotropic serpentine. This material borders the wall of the cavity, encroaching deeply upon its area; centrally, the core of the amygdule is formed by a mosaic of quartz. Epidote is frequently seen in the chloritic matter, and its advancing growth is indicated by a faint shadow margining its edges; this is pleochroic, and recalls the pleochroic halos common in the biotites, but lacks their intensity. Rutile is an occasional inclusion in the amygdular chlorite. One cavity is almost completely filled with augite, decayed centrally, where it is studded with grains of quartz and magnetite crystals.

No. 11.—Locality: southern edge of Klipriversberg Range, about 8 miles south of Johannesburg.

Meg. Resembles No. 10, but the amygdular cavities are larger and are filled with white quartz. Sp. gr. 2·93.

Mic. Ground-mass microlitic as in No. 10. There is less of the opaque matter and more amphibole in needles and wisp-like flakes. Specks of magnetite are fairly plentiful. Many of the amygdular cavities are entirely filled with a mosaic of quartz, which, in turn, sometimes includes a little pyrites and sometimes epidote. Other cavities are filled as in No. 10, and again others carry epidote exclusively.

Eruptive occupying the floor of the Bezuidenhout Valley.

Nos. 12, 13, 14, 15, 16, and 17 as examples.

This rock has a strong likeness to the Klipriversberg amygdaloid; it is separated from it, however, by a large section of the Witwatersrand beds, some 4 or 5 miles of their outcrop intervening between them. The rock is schistose, in places, at the upper, narrower end of the valley. Lower down and beyond the spur of the Witwatersrand Series, which there terminates the northern flank of the valley, the rock comes into relation with that described under No. 7, an intervener between it and the granite.

No. 12.—Locality: Bezuidenhout Valley township, north side of stream, 2½ miles east and a few points north of Johannesburg.

Meg. Closely resembles No. 10. The felspar crystals, however, are small. Sp. gr. 2·87.

Mic. Felspathic microlites are larger than in No. 10, some of them forming small striped laths. Among them is much amphibolic material, in needles and wisps, and a good deal of the opaque white material noted in No. 10. Epidote occurs plentifully throughout the section in irregular grains.

No. 13.—Locality: same as No. 12.

Meg. A weathered specimen, amygdular. The contents of the amygdular cavities have, in many instances, weathered out, so that there is a partial reversion to the original cellular condition, a change reflected in the low specific gravity, viz. 2·47.

Mic. A microlitic ground-mass with occasional members of somewhat larger size. Interstitially there is much chlorite, pleochroic, and nearly isotropic. Scattered abundantly throughout the section are irregular patches of a dark-brown, semi-opaque material, white by reflected light. I believe it to be leucoxene in course of alteration into sphene, and perhaps rutile. Many of the amygdular cavities are empty; where filled, the peripheral portion consists of completely isotropic serpentinous matter, sometimes iron-stained; the central portion is made up of quartz-mosaic.

No. 14.—Locality: from a point lower down the Bezuidenhout Valley, opposite the Geldenhuis tailings-heap.

Meg. A close-grained, bluish-black ground, enclosing opaque-white tabular crystals of felspar. One of these in the specimen measures 2 cm. in length. Sp. gr. 2·87.

Mic. The ground-mass consists of small plagioclase laths of more acid type than the felspathic phenocrysts. These latter are greatly decomposed. They are probably to be referred to oligoclase-andesine. Among the laths lie dirty-green, platy forms with brush-like endings. These are probably hornblendic. There is much epidote, in large irregular grains, sometimes interstitial, sometimes enclosed in patches of chlorite. The amygdular cavities are filled as in previous examples. Some of their chloritic matter encloses biotite, which is apparently growing at its expense. This specimen shows an approach towards the ophitic structure of the diabases.

Nos. 16 and 17.—Locality: Bezuidenhout Valley township, 3 miles east of Johannesburg. Both of these examples are schistose, probably as a result of dynamic metamorphism. The vicinity manifests, as has been pointed out by Drs. Hatch, Corstorphine, and others, a high degree of faulting.

No. 16. Sp. gr. 2·71.

Mic. Individual detail is gone, and the body of the rock is now made up of an exceedingly fine-grained crystalline basis, probably the ground-down fragments of the felspathic microlites and crystals. This ground-mass is traversed by strings of yellowish-green chloritic matter and streaks of iron-staining. These course in rude parallelism, approaching and diverging to leave lenticular interspaces. Large irregular plates, of what is probably titaniferous iron decomposed into a red-stained leucoxene, occur freely, and around these patches the strings frequently wind.

No. 17.—*Meg.* The schistose character is evident in the hand-specimen. Sp. gr. 2·58.

Mic. The general features resemble No. 16. The amygdular cavities are much flattened out. The grains of their quartz-mosaic have sometimes assumed a degree of parallelism, the direction of arrangement being obliquely across the cavity and not in line with its long axis.

Note.—From the foregoing it will be seen that the Klipriversberg amygdaloid and the Bezuidenhout Valley eruptive are much akin.

No. 18.—Locality: an intrusive in the Witwatersrand Series; exposed in Witpoortje Kloof, some 12 miles west of Johannesburg.

Meg. A dark bluish-black rock, holocrystalline, faintly mottled, and of medium grain. Specks of pyrites are conspicuous. Sp. gr. 2·92.

Mic. The rock has the structure of the diabases, large felspathic laths constituting a framework amid which the ferro-magnesian elements are disposed. The felspar is greatly decomposed, but the albite striping is to be made out. The ferro-magnesian constituents are augite and olivine, intermixed in crystalline clusters. Both are faint yellowish-brown in colour. Augite predominates. Both the augite and the olivine are in course of alteration into serpentine, and in both the alteration comes as an opaque cloudiness advancing from the surface inwards. Detached pieces of serpentine and of chloritic matter lie about in the section, the latter enclosing grains of epidote. Large crystalline plates of magnetite are frequent. More rarely, beautiful patches of pyrites occur, arranged in the filigree-like forms it so often assumes.

No. 19.—Locality: surface-exposure 2 miles east of Boksburg. *Possibly of Karoo age.*

Meg. Holocrystalline, bluish-black rock, of fine grain. Sp. gr. 2·95.

Mic. The ground-mass is made up of numerous short laths of plagioclase (with albite twinning) and small irregular grains of augite and olivine; the olivine grains being the larger. These are largely decomposed into a dark, greenish serpentine. Amidst the ground-mass lie larger elements—(*a*) groups of large plagioclase crystals (labradorite); (*b*) occasional large irregular grains of olivine; (*c*) crystalline patches of magnetite; (*d*) irregular green patches of serpentine succeeding olivine; (*e*) a few long, lath-like crystals of twinned augite, sometimes showing erosion. The rock is referable to the olivine-basalts.

Beyond Pretoria.

No. 20.—Locality: from summit of range of hills about 10 miles north of Pretoria, *viâ* Wonderboom Poort, the Poort being a defile in the Magaliesberg Range where river, road, and rail jostle each other in their passage through. The range from which the rock was collected runs nearly parallel with the Magaliesberg. "Pyramids" vicinity.

Meg. A holocrystalline rock of medium grain, dark grey and granitoid. Sp. gr. 2·92.

Mic. A rock of simple constitution, its elements consisting of augite, frequently diallagic; and labradorite; with the allotriomorphic arrangement of the granular rocks. The proportion is about one-third augite to two-thirds labradorite. A gabbro of simple type. The augite is much decomposed and is often turbid. It contains grains of magnetite as decomposition-product. Little patches of chlorite are sometimes included, and, in places, one sees a marginal alteration of the augite sending invading strings of chlorite into the surrounding felspar. The labradorite is comparatively fresh, showing broad albite lamellæ, and, quite rarely, pericline striation.

No. 21.—Locality: outcrop upon the flats midway between Wonderboom Poort and the range from which No. 20 was collected. It probably constitutes part of the same rock-mass.

Meg. A very coarse-grained, holocrystalline rock consisting of large black shimmering crystals set in a white matrix, showing frequent cleavage-faces. Sp. gr. 2·9.

Mic. Large crystals of augite, twinned, with basal cleavage, giving the herring-bone structure, are conspicuous. The crystals frequently show a marginal alteration into brown hornblende. Grouped with the augite are large crystals of hypersthene, partially converted into bastite. Like the augite it too shows a marginal conversion into brown hornblende. The hypersthene is rather more abundant than the augite. The felspar (labradorite) is more decomposed than that of No. 20. It shows much granular opacity. Combinations of Carlsbad, albite, and pericline twinning occur. The crystals are frequently crowded with long needle-like inclusions, whose regular disposition in planes shows an approach to schiller-structure. These inclusions sometimes occupy patchy areas in the interior of a crystal; their extension is attended by a change in the orientation of the axes of elasticity of the felspar. As accessories, a few small zircons are to be seen.

No. 22. An irregular intrusion in the Magaliesberg Series, north of the Van der Merwe Railway Station, Pretoria–Delagoa Bay line.

Meg. A holocrystalline rock of grey colour and fine grain. Sp. gr. 2·69.

Mic. Shows interlacing bars of a greatly decomposed plagioclase interwoven with a rhombic pyroxene, which is mostly altered into bastite. The meshes of this framework are occupied by a micrographic intergrowth of quartz and semi-opaque felspar, the quartz preponderating. Some magnetite occurs, and hornblende, sparingly. A small vein traversing the section is filled with calcite.

No. 23.—Locality: dyke in the Magaliesberg Series, north of Van der Merwe Railway Station.

Meg. Has a general likeness to No. 22, but is of somewhat coarser grain. Sp. gr. 2·83.

Mic. There is a framework of decomposed plagioclase, with rhombic pyroxene as in No. 22, also much quartz in micrographic intergrowth with felspar. In addition there is pale augite partly altered into uralitic hornblende, and plentiful large flakes of ilmenite partly decomposed into leucoxene. Patches of serpentine occur as results of complete decomposition of rhombic pyroxene.

Note.—In no Transvaal instance has the writer observed the violent tingeing of augites so frequently seen where augite is associated with titanium-bearing ores.

No. 24.—Locality: dyke in the Magaliesberg Series, north of Van der Merwe Railway Station.

Meg. A bluish-black rock, of medium grain, partly crystalline. Scratches under the knife. Sp. gr. 3.

Mic. The rock consists of olivine, enstatite, and augite. The olivine is for the most part serpentinized; the decomposition is of the usual type along the cleavage-cracks. The serpentine is greenish, sometimes showing a reddish iron-staining. Where the augite shows change it is in the shape of an advancing cloudiness. The enstatite is fairly fresh, but shows a little of the usual bastitic alteration. Octahedra of magnetite occur. There are also a few flakes of biotite; and, quite rarely, narrow laths of plagioclase.

The rock is interesting as an example of the ultra-basic type.

Vicinity of Klerksdorp.

Locality: ten miles north of Klerksdorp. Intrusive mass occupying the floor of a broad valley between two sedimentary series, usually regarded as being of Witwatersrand age.

No. 25.—*Meg.* A holocrystalline rock of fine grain. Dark-grey in colour. Sp. gr. 2·96.

Mic. Shows numerous plagioclase crystals of small and medium size, among which are disposed fairly large crystals of augite, light yellowish-brown in colour, twinned and herring-boned; also, larger irregularly-shaped crystals of enstatite; neither augite nor enstatite having definite outline. The greater stability of the augite, as compared with the enstatite, is very noticeable, this last showing advanced bastitic change. The felspar crystals are in good condition. They consist of labradorite. Many show beautiful zoning, the zones varying in constitution, and usually following the rule of increase in acidity on passing from core to crust. Sometimes, however, relatively basic and acid zones are seen to regularly alternate. Ilmenite occurs, sparingly, in regular plates, and there are a few scattered irregular grains of magnetite. It is interesting to compare this rock with Nos. 20 and 21 from beyond Pretoria.

No. 26.—Locality: steep, rocky hill behind the old town of Klerksdorp, west of the Schoon spruit.

Meg. A rock with dark-blue, stony ground in which lie opaque, white, quadrangular crystals and glassy-looking blebs. The structure is typically porphyritic. The weathered surface is scoriaceous-looking, owing to the weathering out of the porphyritic crystals; it is inclined to rustiness in colour. Sp. gr. 2·56.

Mic. The ground-mass is micro-felsitic, with some residual glass. Its more transparent portions show vague and ghost-like crystalline outlines, as though the excessively fine granules were on the way to crystalline form. The phenocrysts are: (*a*) Quartz, its crystal outlines rounded off by the magma; the crystals cracked and showing occasional inclusion of the ground-mass. (*b*) Felspar: much decomposed, shows albite twinning, sometimes of exceeding fineness; this is sometimes associated with pericline twinning. It may be regarded, provisionally, as an acid-oligoclase. The edges show irregular corrosion, and there are inlets of the ground-mass within the crystals. (*c*) Orthoclase: in simple Carlsbad twins, clouded like the foregoing, the crystal edges slightly rounded, but not worm-eaten-looking as in the case of the plagioclase. (*d*) Nearly opaque crystals of hornblende; relics of magmatic corrosion. They are recognisable by the shape of their cross-sections and cleavage-fragments. (*e*) Pseudomorphs of green chlorite, following augite. These show a narrow, dark resorption-border. Specks of magnetite and grains of calcite are to be seen in the chlorite. The rock is interesting as a relatively acid type of eruptive, and may be classed as a quartz-porphyry.

No. 27.—Locality: about eight miles N.N.E. of Klerksdorp.

Meg. A bluish-black rock of fine-grained groundwork, which includes many fine, angular, glassy fragments. Sp. gr. 2·68.

Mic. The rock consists of crystalline fragments and lapilli cemented together by a glassy, tufaceous matrix. The crystalline fragments consist chiefly of quartz; they are sometimes rounded, but more often are irregular in shape and sharply angular. The fragments contain the strings of inclusions of the type seen in granitic quartz. Here and there are crystalline aggregates of pyrites, and fragments of microcline and plagioclase. The lapilli vary a good deal in size. A piece of one large one flanks the whole section. It consists of an interlacing framework of plagioclase bars, whose meshes are filled by *opaque*, unindividualised, glassy matter, which is being encroached upon by the surrounding crystals. Many of the smaller lapilli show a similar structure. Others consist of a mosaic of quartz grains, probably with felspathic ones intermixed; the mosaics of varying grain, some being coarser than others. A little calcite is present in irregular patches.

We have probably here to do with a fine volcanic breccia.

Note.—My time at Klerksdorp was limited; the neighbourhood is interesting, and appears to be one around which considerable volcanic activity has been focussed.

No. 28.—An obsidian. This does not fall within the Transvaal Series. It was given to me by Mr. Sydney Ryan, who collected it upon the Lebombo Range, which lies in Portuguese territory, between the eastern border of the Transvaal and the East African coast.

Meg. Has the appearance of pitch. Sp. gr. 2·3.

Mic. The rock consists of a light-brown glass; × 250. The glass is seen to be crowded with trichites disposed almost exclusively in stellate forms, the delicate filaments radiating outwards from a central point. These are, in turn, very frequently arranged in axiolitic strings, running in parallelism along the lines of flow. There are a few spherulitic groups. They give the usual cross in parallel, polarised light. Some of the crosses break up into distinct hyperbolas as the stage is rotated. A few rounded crystals of sanidine constitute the only crystalline elements noted.[1]

IV.—An Occurrence of Scheelite, near Barkerville, B.C.

By Austin J. R. Atkin, Esq.

Lying in the heart of the gold belt known as the Barkerville District, Hardscrabble Creek was discovered by the pioneer prospectors in 1867, and has ever since been noted for the number of heavy minerals associated with the gold. Galena and various iron minerals were recognized, but the most troublesome was a heavy white substance, which caused great trouble to the miners by packing in the sluice-boxes so tightly that the gold was carried over the firmly set particles by the amount of water required to keep the riffles clean. An investigation by an economic geologist of high standing of some lumps of the alleged mineral showed it to be barium sulphate, and no examination was made of the smaller particles.

Last Winter the author was asked to suggest some possible way of getting rid of this most troublesome mineral, and went down to see the workings. While there some mineral was noticed that was certainly not barytes, and a careful examination—since checked many times—showed the presence of scheelite of good quality. Shortly after the author's examination the white mineral disappeared, so he advised a careful search for the reef, or deposit, close to the face being worked at that time. Very little search revealed this interesting deposit, the second instance of the ore being discovered in British Columbia, and the only deposit in the province that shows any chance of proving of economic importance. The ore occurs in a zone of country rock, altered by the infiltration of silica and calcite, bounded on the north by an altered mica-schist. The width of the altered zone has not yet (August, 1904) been determined, but it has been proved scheelitiferous for a width of about 12 feet.

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[1] The thin sections were cut for me by Mr. Gregory, Mineralogist, of Kelso Place, South Kensington.

The ore so far developed seems to occur under two distinct conditions, as an associate mineral with iron pyrites and galena in small quartz veins; and in 'vugs' in the country rock, sometimes quite pure and at others mixed with a little quartz. The undetermined dark mineral—columbite (?)—occurs in such small quantities as to be of no value. No decomposition products of scheelite have so far been discovered, although the enclosing schist is much discoloured and altered by infiltering solutions.

The discovery of this rare earth in a place well known for so many years should be remembered when in districts which have been much less thoroughly explored, in which an examination of the heavy materials recovered in the process of Placer Mining may show rare minerals of the greatest economic importance.

NOTICES OF MEMOIRS, ETC.

NOTES ON THE GEOLOGY OF CYPRUS TO ACCOMPANY A GEOLOGICAL MAP OF CYPRUS. Compiled by C. V. BELLAMY, F.G.S., M.I.C.E., F.R.M.S., late Director of Public Works in Cyprus. Small 8vo; pp. 16. (London: Edward Stanford, 12, 13, and 14, Long Acre, W.C., 1905. Price 6s.)

THE Geological Map of Cyprus[1] and the descriptive text accompanying it are the result of observations extending over a period of five years during which Mr. Bellamy was stationed in the island. He acknowledges the assistance he has received from Mr. A. J. Jukes-Browne[2] and Dr. J. J. H. Teall.

The following is an abridged account of Mr. Bellamy's description of the island:—

1. *Physical Features.*—The Island of Cyprus lies in the extreme eastern basin of the Mediterranean Sea, its distance from the shores of Syria on the east and Asia Minor, or, as it is called locally, Anatolia or Caramania, on the north being about 60 miles in each case. It measures about 140 miles from south-west to north-east, and about 60 miles from north to south; it contains some 3,584 square miles.

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[1] Printed in colours; size, 30 by 22 inches; scale, 5½ miles to an inch (1: 348,480). [The actual size of map to the margin of the engraved plate is 24 by 18 inches.]

[2] See also paper by C. V. Bellamy and A. J. Jukes-Browne read before the Geological Society of London, January 4th, 1905 (GEOL. MAG. for February, 1905, pp. 87–88).

The coastline is very irregular and indented with several extensive bays, the chief of which are those of Famagusta, Larnaca, Limassol, Akrotiri, Krysokhou, and Morphou. About midway along the southern seabord is the irregularly rectangular promontory of Akrotiri, on which is situated the Limassol Salt Lake; this promontory culminates to the south-east in the conspicuous headland of Cape Gata. In the north-east the island tapers off into the remarkable peninsula of the Carpas, which is some 50 miles long and nowhere more than 7 or 8 miles wide, terminating in Cape Andreas, off which is situated the group of barren rocky pinnacles comprising the Klides Islands.

South of Famagusta is the rugged headland of Cape Greco, backed by a table-topped rock, a striking feature to navigators, while at the western and north-western end of the island are Cape Epiphanios or Acamas and Cape Kormakiti.

The island is very mountainous. Along the northern seabord stretch the Kyrenia Mountains from Cape Kormakiti until the Carpas commences, and many of their summits exceed 2,000 feet in height, the range culminating in Buffamento, 3,135 feet. In the south-west central portion of the island rise the great masses of the Troödos Adelphi and Olympus Mountains, the summit of the first being Mount Troödos or 'Khionistra,' 6,406 feet above the sea. The general trend of the mountain ranges is in an easterly and westerly direction.

Between these two ranges lie the central plains of the Mesaoria extending from Morphou on the west to Famagusta on the east. These lands, which comprise the washings of centuries from off the adjoining mountain slopes, are of great fertility and are given over to the cultivation principally of cereals, to which, indeed, the whole of the low country is devoted. The mountain slopes are appropriated to the cultivation of the vine, and the summits are clad in pine-trees, ilex, arbutus, juniper, etc. The deep and narrow valleys which seam the mountains enjoy great richness of soil, which yields successive crops of wheat, barley, cotton, maize, millet, potatoes, etc., and supports the olive, mulberry, cherry, hazel, walnut, fig, apricot, apple, and fruit trees of various kinds.

The geology of Cyprus was dealt with exhaustively by M. Albert Gaudry in the "Mémoires de la Société Géologique de France," ser. II, vol. vii (1862), to which a map was attached, but the latter was compiled from a previously existing rough survey of the island of doubtful accuracy. Other writers include MM. Unger and Kotschy, "Die Insel Cypern" (Vienna, 1865), and Mr. R. Russell, C.E., in a "Report on the Existing Water Supply of the Island of Cyprus" (Foreign Office, 1881).

A map of the island on a scale of one inch to a mile, prepared from a trigonometrical survey, executed under the direction of Captain H. H. Kitchener, R.E., was published in 1882. A smaller map, reduced from the Government Survey, has furnished the author with a basis for the geological map noticed in this key.

TABLE OF FORMATIONS.

AGE.	CHARACTER.	DISTRIBUTION.	LOCAL DEFINITION.
Cretaceous.	Compact limestone, marble, etc., and associated igneous rocks.	Kyrenia Mountains and Paphos District.	Trypanian, derived from Trypa Vouno, a summit of the Kyrenia Range.
Highest Cretaceous and Lower Eocene.	Not represented in Cyprus.		
Upper Eocene.	Sandstone, shales, grey marls, conglomerates, and breccia.	Flanks of the Kyrenia Mountains, north and south side of Central Plains, Carpas, and Paphos.	Kythræan, from Kythræa, in the neighbourhood of which this series reaches its greatest development.
Oligocene.	Grey marls, yellow and grey-green clays, gypsum, selenite, alabaster, etc. Tabular white calcareous marls, chalk, flint, sub-crystalline limestones.	North coast, Carpas, north and south of Central Plains, north, east, south, and south-west of Troödos Range.	Idalia beds, derived from Dali, ancient Idalia, where these marls reach marked development. Athienou stone, etc.
Break.	Igneous rocks of the	central and southern	areas.
Pliocene and Pleistocene.	Calcareous sandy limestone, hard or friable. Sands, conglomerates, alluvium.	Low country generally, coast littorals, Central Plains, Foot Hills, etc.	Kyrenia rock, Nicosia Beds, Ag. Paraskevi, Famagusta, Cape Pyla, and Ag. Phyla Stone.

2. *Trypanian Limestone of the Kyrenia Mountains, etc.* (*Cretaceous*). The areas occupied by this formation are indicated on the map in pink. The Kyrenia Mountains constitute the northern rampart of the central plains of the island, and commence at a point about 6 miles eastward of Cape Kormakiti on the northern seabord. The spot is known as 'Skasmata,' a term suggestive of the peculiar physical features of the neighbourhood. From this point, for a distance of 28 miles, the range trends in a direction east by south, and in the neighbourhood of Kythræa changes towards east by north for 30 miles to Komi Kebir at the commencement of the Carpas. Though its extreme length is 58 miles the formation is nowhere more than 3 miles wide, and as the summits of the range frequently reach an altitude of between 2,000 and 3,000 feet, some idea may be gathered of the precipitous nature of these mountain slopes.

The whole of this range consists of hard compact limestones, except for occasional intrusions of igneous rock, and with the exception of a small outlier near Akourso in the Paphos District, these limestones are not encountered in any other part of the island. The characteristics are compact limestones and marbles of several kinds: white, cream colour, or veined with yellow. They are usually very hard, and include a large variety capable of yielding decorative stone of considerable beauty.

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These limestones and shales are the oldest rocks in Cyprus, and form the foundation on which the rest of the island has been built up. Gaudry remarked that they bear much resemblance to the Cretaceous rocks in other parts of the eastern Mediterranean basin. He compared them with the Hippurite Limestones of Attica, since assigned to the Cretaceous age, and estimates their thickness at 6,500 feet. There is a striking and apparently entire absence of fossil remains in this formation, which causes some doubt as to its correct classification.

At intervals along the axis of the Kyrenia Mountains there occur masses of igneous rocks which have intruded into or through the limestones. These are coloured brown on the map. Their presence may be responsible for the production of the more crystalline varieties of limestone by contact-metamorphism, but the general compression and uptilting of the beds has probably been accomplished by earth-movement which produced the long anticlinal axis of the chain, and so steep is the angle of this axis that the beds are frequently in a nearly vertical position.

Specimens recently collected and submitted to Dr. Teall include augite-biotite-syenite, ophitic olivine-dolerite, and decomposed liparite, from the gorge of the Panagra River near Myrtou; rhyolite or white quartz-felsite near Pentadactylos; with jasper from near Buffamento and other localities.

3. *The Kythræan Series* (*Upper Eocene*).—This is a formation of sandstone and shales. It is indicated on the map by a green tint, and its beds flank the northern mountains both along their north and south sides, extending from Cape Andreas on the east to Morphou Bay on the west; they also occur on the southern and western slopes of the southern or central range.

* * * * * *

The greatest development to which these beds attain occurs in the neighbourhood of Kythræa, consequently it has been considered convenient to call them the 'Kythræan Series.' They consist of calcareous sandstone shales, brown, grey, or grey-green in hue, and on the southern slopes of the Kyrenia Range, where they are most marked, present a series of billowy undulations, which, since the British occupation of Cyprus, have been known as the 'Hummocks.'

The conglomerates of this series are seldom found except on the slopes of the Kyrenia Mountains in the neighbourhood of the Trypanian limestones; they contain fragments of rock which undoubtedly belong to the latter, but have been separated therefrom and incorporated in the more recent formation. The best instances of the occurrence of these conglomerates are at St. Catherine's Pass, the Akanthou Gap, and east and west of the village of Akanthou; they have not been observed in any force elsewhere. Their constituents are principally water-worn fragments of Trypanian limestones, marbles, and flints.

The breccias are compounded of unworn fragments of the older Trypanian limestones, and are of frequent occurrence along the flanks of the Kyrenia Mountains. They vary in hue and are either blue, pink, yellow, brown, or white, and at times they combine fragments of all these varieties, producing an agreeable effect.

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No fossil remains have yet been found in any part of the Kythræan Series.

Gaudry's description of these beds, as corresponding with the Macignos of Italy, would appear to place them alongside the tassello or allied to the Vienna sandstones or 'Flysch.' They belong probably to the Upper Eocene series. Having regard to the frequent flexures and undulations of these beds, I doubt if their thickness amounts to more than 2,000 feet, though Gaudry put it at 6,000.

4. *The Idalian Series* (*Oligocene*).—Probably the most characteristic of the geological formations represented in Cyprus are the grey friable and the white calcareous tabular marls, the latter of intense whiteness. Occasionally they pass into pure chalk, and in many localities contain quantities of flint—pink, greenish, or translucent—occurring in bands of from four to six inches in thickness. In the grey marls of the Oligocene are intercalated large masses of gypsum and selenite, but their prevailing characteristic is friable matter, yellow, brown, or grey-green, of the consistency of clay.

These two groups of beds are distributed all over the island, and are indicated on the map by a yellow tint. The white marls reach their greatest development on the southern side of the great igneous masses of the Troödos Range. From the neighbourhood of Kophino and Lefkara right through the southern slopes of these hills, they are in great force.

It may be remarked that the white marls occupy that part of the island where the best wine comes from. The so-called 'Wine Villages'—Ag.[1] Ambrosios, Mallia, Vasa, Omodhos, Kilani, etc.—are all within this area, and in this neighbourhood the aspect of the country resembles the wide rolling downs and chalk hills of Wiltshire, but the illusion is dispelled when one perceives the deep gorges with their precipitous sides in which the torrents flow.

The intense whiteness of these tabular marls has, no doubt, a considerable influence upon the temperature of the atmosphere over the region where they are found. The glare from the white soil is extremely painful to the eyes, necessitating the use of coloured glasses to protect them; and the heat thrown back from the bare white rocks is frequently intolerable, aggravated as it is by the infrequency of foliage and shelter-giving trees.

In the neighbourhood of Dali, where the conspicuous development of white marls and limestones would seem to have suggested to Russell the adoption of the term 'Idalian' to define them, great rounded hills occur in a succession of undulations extending from the neighbourhood of Margi on the west to Athienou on the east, parallel with the Idalia, or Yalias River.

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[1] Ag. (incorrectly printed "Ay." in Mr. Bellamy's Key to the Map of Cyprus) is a contraction for Ἅγιος, Haghios, = *Saint*, prefixed to many names of towns and villages in Cyprus.—*Edit. Geol. Mag.*

At Athienou these beds pass into a massive granular limestone, of finer quality and less density, which yields a very useful material known as Athienou Stone, easily cut and much used in the manufacture of a number of different utensils for domestic purposes.

Near Psathi, compact and massive beds of fine-grained gypsum of straight cleavage are worked for the extraction of paving slabs known as 'marmoras.' Their cleavage is very true and even, and their texture is such that they can be cut with a saw and smoothed with a plane. These beds also contain a quantity of native sulphur, in veins and nodules.

Ochres are found principally at Mavrovouni near Larnaca, and also near Limassol, where they are worked for terra umbra, a considerable export trade in which is carried on.

Fossil remains are not numerous, except among the white, compact, chalky marls, which contain a few shells and Echinoderms similar to those to be met with in Malta and Sicily. Some of the limestones, however, are largely made up of the minute shells of Foraminifera, and resemble the Globigerina limestones of Malta.

With regard to thickness, it is not easy to give an estimate because of the frequent flexures, but they probably range from 1,500 to 2,000 feet.

5. *The Igneous Rocks of the Central Mountains.*—These rocks form a tract of mountainous ground which extends for a distance of about 60 miles, with an average breadth of 17 or 18 miles. It includes the mountain groups known as the Machera on the east, the Adelphi and Troödos Ranges in the centre, and the Tillyria Mountains on the west; it extends from a point a few miles to the north-west of Larnaca to the shores of Morphou and Krysokhou Bays in a continuous mass. North-east of Larnaca is an inlier in the neighbourhood of Stroullos and Mavrovouni, and another smaller isolated outcrop occurs near Petrophani to the westward of Athienou on the main road, and about half-way between Nicosia and Larnaca.

In the district of Paphos and in the extreme western end of the island are other outcrops, such as that near Fontana Amorosa, near Ag. Epiphanios, Cape Acamas; at Ag. Ismenas, Ag. Yeorghi, Cathika, and Akourso.

The central mountains are the highest ground in the island, and include the great dome-shaped mass of Troödos, the summit of which, 'Chionistra,' is 6,406 feet above the sea, and the Adelphi Range, which culminates in a height of 5,305 feet.

The areas occupied by these rocks are coloured brown on the map.

The ophitic rocks Gaudry calls ophitones and spilites. These terms are now obsolete, but were formerly applied to the rocks which are now known as diabase and dolerite; he also describes a spherulitic rock, which seems to correspond with that now known as variolite. These are all composed of labradorite-felspar and augite. Aphanites, or fine-grained diabases, also occur.

Basaltic rocks are of frequent occurrence, especially in the Tillyria district; specimens obtained there by me have been identified by Dr. Teall as basalt, and one as augitite, a rock of the limburgite group, but without any olivine.

The serpentine rocks occupy the region of the highest mountains of Troödos, and are bounded by Troöditissa on the south and Evrychou on the north, while they also occur at Phinicarga, Akourso, Cathika, Ag. Nicola, and Ag. Aconas in the Acamas. On the south and east slopes of Troödos they are fibrous and laminar in texture, and contain asbestos.

The eupholites or felspathic serpentines form an intermediate stage between the serpentine and granitone or euphotide, and abound on the side towards Prodromos.

The gabbros are found towards Evrychou and from Prodromos to Akourso. They occur in bands among the masses of diabase and aphanites about Kykkou and again at Ag. Nicolaos in the Acamas.

Diabase is the variety most prevalent among the igneous rocks of Cyprus. They are generally fine-grained, of a grey-green, blackish, or dull-green hue; frequently much weathered, broken up and decomposed, particularly in the neighbourhood of the sedimentary rocks.

Where the Pliocene rocks rest on these igneous rocks they are not altered, and this fact proves that the intrusion of the volcanic rocks took place in the interval between the formation of the Oligocene and Pliocene rocks of Cyprus.

6. *Pliocene and Pleistocene.*—The deposits comprised in the more recent formations, namely, the Pliocene or later Tertiary, and the Pleistocene or Quaternary strata, are indicated on the map by a blue tint.

They extend over the Central Plains, the coast littorals, and are distributed over the foot hills and low country generally, and they rest unconformably on all the older rocks. The Pliocene is represented by calcareous sandstones, conglomerates, sands, and calcareous tufa, while the Pleistocene beds comprise principally gravels, travertine, the alluvial deposits of the Mesaoria, and the raised beach sandstones of the sea-shore. They may be classified under the following heads, namely :—

Kyrenia Rock } Calcareous sandstones and marls.
Nicosia Beds }
Raised beaches.
Conglomerates.
Alluvium.

The two first names were adopted by Russell to indicate certain variations of the same formation, soft limestones formed from calcareous sands and consisting almost entirely of minute organic débris, small worn fragments of shells and other marine organisms, loosely compacted together and containing a small percentage of quartz sand. Both are of Pliocene age.

The beds vary slightly in texture, sometimes compact and durable, and at other times soft, friable, and soiling the hands. They are almost invariably disposed in horizontal beds, having a surface coating or crust of tufa-like carbonate of lime. They vary also in colour between light yellow to reddish brown, but its hue is seldom any criterion for its texture. Those beds are found principally at Kyrenia, a little to the west of the town, at the hill of Ag. Paraskevi, Nicosia, at Famagusta, near Cape Pyla, and Cape Gata, where the quality, appearance, and texture are all very similar, namely, semi-compacted, buff-coloured, and easily worked with the tool.

At Yeri a darker, harder, and finer-grained material occurs. Near Kalopsyda and Kouklia sepia-coloured, fine-grained, friable freestones are found in extensive masses. Near Strongylo and Vatili they are straw-coloured, very friable, and fine-grained, having little or no durability. Near Kyra is a coarse-grained rock, reddish or brownish in hue, and of a durability equalling, if not surpassing, that of the Ag. Paraskevi rock.

At Ag. Phyla, near Limassol, are extensive quarries of a fine-grained, light-yellow, compact stone, possessing many good qualities. At Paphos the texture is coarse, less compact, and more friable than is found among the coarse-grained qualities. It is dark brown in colour. At Skoulli, in the valley of the Krysokhou River, a compact, fine-grained, light-yellow rock is found with horizontal veins or bands of dark-grey or greenish-grey matter.

From Yerolakko, on the west of Nicosia, following the banks of the Pedias River as far as Deftera, are large masses of the fine friable yellow variety, changing towards Aradiou into a clayey sand, alternately dark brown or grey green, suggestive of the presence of glauconite. The argillaceous beds near Deftera contain numerous Oyster shells—*O. edulis.*

Towards Laxia, south of Nicosia, are extensive deposits of oyster shells, from the abundance of which is derived the name 'Ostrakoudhies,' given to a prominent hill on the west side of the main road from Nicosia to Limassol. Great masses of friable rock are found towards Ag. Sogomenos, where the texture is very variable and has produced striking results during the process of weathering.

7. *Brief Summary of the Physical History of the Island.* — The oldest strata represented in Cyprus are the Trypanian limestones, the characteristic element of the Kyrenia Mountains. They have been assigned to the Cretaceous age, and form the foundation or platform on which the newer rocks have been laid down. Apparently they formed part of an ancient land-surface during the greater part of the Eocene period. Then came a subsidence of this land beneath the sea, and in this sea were deposited the sandstones of the Kythræan Series, which is referred to the latest part of the Eocene period.

The absence of fossil remains in the older strata led some Continental geologists to believe that their deposition took place at so great a depth under the sea as to be below the zone of life, presumably in Mediterranean waters; but so far as the Kythræan beds are concerned this is disproved by the discovery of tests of Globigerina in a slice of Macigno by Mr. Jukes-Browne. The gritty material of these calcareous sandstones is, however, of volcanic origin; they may, in fact, be accumulations of volcanic dust and felspathic grit ejected from a volcano, and spread out over the sea-floor of the period.

The absence of organic remains in the Trypanian limestones may be accounted for by marmorosis and other metamorphic changes which have taken place since they were originally deposited.

Above the Kythræan Series come the grey Oligocene marls, containing gypsum and alabaster, and above these the white (Idalian) marls and chalks, which prove that the subsidence had continued until the water was of great depth and deposits similar to modern oceanic oozes could be formed. The subsidence was brought to an end by an epoch of volcanic disturbance accompanied by general upheaval. The Pliocene strata of Cyprus rest unconformably upon the older rocks, and moreover they belong to the younger members of that series, so that here we have a second break in the geological history of the island. During this interval, and at a time corresponding with the early Pliocene stage, the igneous rocks would appear to have emerged and the mountain ranges came into existence, only the summits of which, however, then showed above the sea, constituting groups of islands, now the Troödos Mountains on the south and the Kyrenia Hills on the north. Among these islands spread the waters of the Pliocene sea, beneath which the sandstones, conglomerates, and associated strata, all fruitful in fossil remains, were being deposited. Subsequently the waters receded and revealed the island, whose emergence may have been perpetuated in the fable of Aphrodite rising from the waves. This introduced the Pleistocene period. Later came high elevation and torrential floods, which were responsible for much of the land sculpture, and which changed the physical aspect of the country into the condition in which it is now found. May it not be assumed that this event also is still recorded in the annual ceremony of the 'Kataklysmos'?

Recent discoveries in Egypt and Syria indicate that in early Pleistocene times there existed, to the south of Cyprus, a great inland sea, leaving dry land all around Cyprus, which connected it with the mainland of Asia on the north and with Syria on the east. It was at this period that the mammalia, whose remains have recently been discovered by Miss D. M. A. Bate in the Pleistocene deposits of the caves among the Kyrenia Mountains, made their way over from the mainland. They were no doubt denizens of the great plains, now submerged, which separated the mountains of Cyprus from those of Syria and Asia Minor, and whose grazing-grounds were subsequently restricted to the estuaries of the Pedias and Yalias, where now stretch the fertile corn lands of the Eastern Mesaoria.

8. *Economics.*—The industrial uses to which the rocks of Cyprus

are put are numerous and varied, and, according to tradition, the island possessed at one time great mineral wealth, but there are now few indications of the presence of ore of any description in quality or quantity sufficient to encourage systematic mining operations.

The following are among the principal products of the rocks of Cyprus:—

FORMATION.	PRODUCTS.
TRYPANIAN LIMESTONE (Cretaceous).	Marble of various kinds, formerly used by the ancients in their temples and palaces. Lime, produced at Kythræa, Dikomo, Kazaphain, etc. Clay, used for covering the flat roofs of the native houses.
IGNEOUS ROCKS.	Copper, according to tradition. The only mine now working is at Lymni, in the Paphos District. Iron pyrites in abundance. Asbestos, among the serpentines of Troödos. Puzzolana. Terre verte. Alum. Pottery earth. Gems, rock crystal or 'Papho diamonds.' Road-metal, etc.
KYTHRÆAN SERIES (Eocene).	Building-stone. In some localities a clay is found containing a small percentage of carbon.
GREY MARLS (Oligocene).	Gypsum, for plaster of Paris. Alabaster and selenite. 'Marmoras' or paving slabs. Sulphur.
WHITE TABULAR MARLS (Oligocene).	Athienou stone, for fire bricks, hearthstones, domestic utensils of various kinds. Flint, for 'dhoukanis,' a species of threshing implement. Terra umbra. Building-stone. Road-metal, etc. Mineral springs are also found issuing from these marls impregnated with sulphur.
PLIOCENE AND PLEISTOCENE.	Building-stone, etc. Salt, from the salt lakes of Larnaca and Limassol. The alluvial deposits of the Mesaoria are remarkable for their depth and loamy character, constituting a soil of great fertility, and eminently suited for the cultivation of cereals, etc.

REVIEWS.

I.—PALÆONTOGRAPHICAL SOCIETY OF LONDON, Vol. LVIII. Issued for 1904. (London: printed for the Palæontographical Society; agents, Dulau & Co.; December, 1904.) Containing 28 pages of introductory matter, and—

1. The Fishes of the Old Red Sandstone, Part II, No. 2; by Dr. R. H. Traquair, F.R.S., F.G.S. pp. 27, illustrated with 8 plates and 10 text-figures.
2. The Cretaceous Lamellibranchiata, Vol. II, Part 1; by H. Woods, M.A., F.G.S. pp. 56, with 7 plates and 6 illustrations in the text.
3. The Carboniferous Lamellibranchiata, Vol. II, Part 3; by Dr. Wheelton Hind, F.G.S. pp. 91, with 4 plates and 3 text-figures.
4. The Inferior Oolite Ammonites, Part XII; by S. S. Buckman, F.G.S. pp. 103, with 5 plates, 140 text-figures, and 3 supplement plates of radial lines.
5. The Lower Palæozoic Trilobites of Girvan, Part II; by F. R. Cowper Reed, M.A., F.G.S. pp. 47, with 7 plates.
6. British Graptolites, Part IV; by Miss Elles and Miss Wood. Edited by Professor Lapworth, F.R.S. pp. 64, with 6 plates and 33 text-illustrations.

THE volume now issued is one of extreme interest, and is specially deserving of attention on account of the great variety of subjects dealt with in its 416 pages, illustrated by 37 quarto plates, 192 text-figures, and 3 tables of radial lines of Ammonites.

1. Dr. R. H. Traquair, the archichthyologist of the Palæozoic rocks, gives us descriptions and figures of Old Red Sandstone fishes of the genera *Pterichthys* and *Bothriolepis*, accompanying his descriptions by admirable restorations in the text, which will be of the highest zoological value to all who take an interest in these very early forms of armoured notochordal fishes, to the study of which the late Hugh Miller was one of the first to direct scientific attention and to attempt to restore.

2. Mr. Henry Woods' descriptions and figures of species of Pectens and Limas, so numerous in our Chalk formation, will prove extremely serviceable to collectors of these Cretaceous molluscs. If we compare these seven plates and text-figures with similar drawings executed 50 years ago, we cannot but be struck with the great advance made in art and the admirable quality of the illustrations now presented in these latest volumes of the Society's publications.

3. Dr. Wheelton Hind continues his work on the bivalve Mollusca of the Carboniferous period. The figures are extremely good, and the author gives carefully prepared tables of zonal and geographical distribution, which will greatly assist the work of the Committee in completing, as far as possible, their record of the life-zones of the Carboniferous rocks and the correlation of their several horizons over the British area. Few workers at palæontology in this country have displayed more energy and earnestness in carrying out their special line of scientific research than Dr. Wheelton Hind, and notwithstanding his arduous professional duties there are not many Geological Museums, or localities in the Carboniferous of Great Britain and Ireland which he has omitted to visit for study and examination.

4. Mr. S. S. Buckman gives in a Supplement to Part XII a revision of and additions to the Hildoceratidæ. The figures in the text, as well as the plates, are excellent, and will no doubt prove of service to the workers at Inferior Oolite Ammonites. In this supplement the author gives in 96 pages of text brief descriptions of upwards of 200 species referred to 51 genera of Hildoceratidæ. These are illustrated by 5 plates, containing 137 figures, 3 supplementary plates or tables of 161 'radial lines,' and 140 figures and outline figures in the text.

The labour involved in this task must have been immense, but it may be doubted whether so elaborate a system of specific determinations of a single family of Ammonites can be adopted and carried out by the ordinary museum worker or the private collector. Surely such minutiæ involve almost a specific determination and name for every single Ammonite discovered in each bed. Assuming these Cephalopods to have been gregarious in their habits, like so many other molluscs, and remembering that all gregarious species have considerable individual variability among themselves, it would seem almost as feasible to make numberless species of the slight variations in the crowds of *Buccinum*, *Fusus*, *Nassa*, and *Trochus*, or the many coloured Pectens dredged along our coast. There are, however, many entomologists (especially among the Lepidopterists) who think it lawful to make new species and even genera out of the local varieties of the butterflies which inhabit each separate valley of a single mountain range. Therefore, let the palæontologist also indulge in an outburst of species if he so pleases, but we need not follow the author any further in fissiparism than we feel disposed.

We cannot avoid touching upon one other point, namely, the very complex terms introduced by the author in his description of species, which seem calculated, like a hedge of 'prickly-pear,' to repel the student who may desire to penetrate to the hidden treasures of knowledge which lie within. Here are one or two examples of word-construction by the author, taken at random :—

Pseudogrammoceras placidum, Buckman, is described as "substeno-subleptogyral, perlatumbilicate; parvicostate to striate. (*Immature example*) . . . subplaty-subleptogyral latumbilicate" (p. cliii).

"In many genera, the concavumbilicate Ammonites, for example, and forms of the *Hyperlioceras*-type, the leptogyral species do not show expansion of umbilicus until angustumbilication has first been obtained, and often, too, not until the ribs have been lost" (p. cxliv).

The genus *Pseudogrammoceras*, S. Buckm., is defined as "sub-platy-subleptogyral; latumbilicate; subdensiseptate, sublongi-sub-latilobate; laterally flexiradiate; peripherally acutanguliradiate, convex to convexifastigate altisepticarinate" (p. cxliii).

These descriptions need very careful consideration and study before they are adopted.

5. Mr. F. R. Cowper Reed devotes another section of his monogragh to descriptions of the Lower Palæozoic Trilobites of Girvan, comprising species of *Asaphus*, *Illænus*, *Cyclopyge*, *Proetus*, *Bronteus*,

Lichas, etc., largely from materials furnished by Mrs. Gray, of Edinburgh, the Museum of Practical Geology, the Edinburgh Museum, the Woodwardian (Sedgwick) Museum, etc.

We wish that the author had found it possible, in cases of fragmentary specimens, such as several of these species are based upon, to have given in outline a restoration of some of the more important forms; this would have greatly enhanced the value of this very useful work, and might even now be added as a final plate, if thought desirable.

6. Miss Gertrude L. Elles and Miss Ethel M. R. Wood, aided by Professor Chas. Lapworth, continue their monograph on British Graptolites (pt. iv), dealing with the history of research and the family of the Dicranograptidæ, following with the genus *Dicellograptus* and nineteen species and varieties duly characterized and figured, then the genus *Dicranograptus* with thirteen species and varieties. These are illustrated by numerous text-figures and six quarto plates by Bemrose from drawings by Miss Wood.

In commending the work of this Society, which consists in publishing figures and descriptions of every British fossil, and has now been carried on continuously for fifty-eight years, it is hardly needful to mention that, apart from covering the bare cost of the production by artists, process-engravers, printers, etc., and for paper and other necessary expenses, the whole income of the Palæontographical Society is returned to the subscribers in the annual volumes they receive. Nay, more, owing to the greater amount than usual of plates and letterpress prepared by authors for publication in the years 1903 and 1904, the cost of these volumes has largely exceeded the Society's income for those years, so that each contributor of one guinea has really received back a volume costing the Society two guineas in return for his subscription, which has been paid for out of the small savings of past and more prosperous years. It should also be mentioned that the authors of monographs receive no remuneration whatever for their contributions, which are freely presented to the Society.

The only source for regret arises from the fact that owing to the death of many old members, and the want of a sufficiently large number of new ones coming forward to replace their loss, the income of the Society is considerably diminished, and its most valuable work will be greatly retarded in the future unless geologists, palæontologists, and biologists—indeed, naturalists generally—will unite to assist the Society to carry on its work successfully in the new year. Certainly all Literary and Scientific Institutions, Public Libraries, and private persons desirous to promote the study of palæontology should join the ranks and send in their names to Dr. Arthur Smith Woodward, F.R.S., Natural History Museum, Cromwell Road, S.W., the able and energetic Secretary, who will take care that the annual volume of the Palæontographical Society is duly delivered, carriage paid, to the address of each subscriber.

II.—Memoirs of the Geological Survey of England and Wales. The Geology of the South Wales Coalfield. Part V: The Country round Merthyr Tydfil, being an account of the region comprised in Sheet 231 of the map. By Aubrey Strahan, M.A., F.R.S., F.G.S., Walcot Gibson, B.Sc., F.G.S., and T. C. Cantrill, B.Sc. pp. viii and 132, with 2 plates and 12 figures in the text. (Wyman & Sons, 1904. Price 1s. 6d.)

THIS is the fifth part of the Memoir on the Geology of the South Wales Coalfield, and is descriptive of Sheet 231 of the New Series one-inch map. This sheet includes a small tract of the Pennant plateau and that portion of the north crop of the coalfield which extends from Dowlais to Swansea Vale. The northern half of the map is occupied by the scarps of the Lower Carboniferous rocks and by the long dip-slopes of Old Red Sandstone, which form the Fforest Fawr and lead up to the Brecknock Fans.

The Old Red Sandstone includes an upper and impersistent subdivision of grey grits and conglomerates, which is developed round parts of the Carboniferous tract. The grits pass up into the Carboniferous Limestone, and are known from fossil evidence, obtained further to the east, to be of Upper Old Red Sandstone age. The great mass of 'Brownstones' lying below the grey strata has yielded no fossils in this area, and is doubtfully referred to the Lower Old Red Sandstone. The lowest strata exposed are some green and red sandstones and marls which have been named after the Senni Valley, where they were first distinguished. One of the finest exhibitions of the characteristic scenery of the 'Brownstones' (which appear to be the backbone of the Old Red in this area) may be seen from the northern edge of Bryniau Gleision. On the far side of the deep Glyn Collwng a plateau, formed by the hard uppermost rocks, slopes gently upwards towards the north to a height of nearly 3,000 feet. Though once continuous, this long slope has been deeply trenched by stream-action into separate hill masses, each with a flat top bordered by precipitous escarpments. This is the structure of the well-known Beacons of Brecon (Pen y Fan, 2,906 feet, and Corn Du, 2,863 feet), each of which supports a small but characteristic outlier of the plateau beds consisting of well-bedded flaggy red sandstone, in which occur a few scattered quartz pebbles.

The Carboniferous Limestone Series includes the Lower Limestone Shales below the main mass of limestone, and a thin impersistent set of shales with thin dark limestones above that mass. These dark limestones towards the top of the series present the somewhat exceptional feature of weathering at the outcrop into rottenstone, which has been exploited here and there to a considerable extent, the best quality fetching £10 a ton. Analyses have been made with a view of ascertaining what has occurred in the conversion of the black limestone into rottenstone. A sample of the limestone contained about 16 per cent. of silica. "A few very small cubes of pyrites and flakes of colourless mica are the only visible impurities: there is no detrital quartz, and the silica shown in the analysis must exist as a thin framework of chalcedonic character between the calcite grains." What has happened is that the carbonates have been removed, leaving behind siliceous matter of the above peculiar character. As much as 80 per cent. of this siliceous material is found in the best samples of rottenstone, whilst alumina and ferric oxide are in less amount than is the case in inferior samples.

In the Millstone Grit three subdivisions are made, the most conspicuous member being a massive quartz-conglomerate at the base of the formation. The fossils yielded by some shaly bands show that marine conditions prevailed during the deposition of strata of Coal-measure aspect. Upwards the Millstone Grit graduates into the Coal-measures, the upper and lower limits of the Farewell Rock being ill-defined. As regards fossils from the shales of the Millstone Grit, as many as 17 localities are given, some belonging to another sheet, whilst the species quoted include *Spirorbis pusillus*, *Lingula mytiloides*, *Orthis Michelini*, *Productus semireticulatus*, *Spirifera glabra*, two species of *Carbonicola*, *Pterinopecten papyraceus*, *Gastrioceras carbonarium*, *Gliphioceras reticulatum*, etc. Mr. Strahan observes that, as a general rule, *Carbonicola* occurs in the upper part of the shale, while purely marine forms such as crinoids, brachiopods, and cephalopods are confined to the lower part.

As regards the Coal-measures, the same author observes that the part of the North Crop included within the area under description extends from the anthracitic region of Ystradgynlais to the steam-coal region of Dowlais. While not always recognizable individually, the lower coals as a group can readily be identified in the two regions. The nine-foot seam of Dowlais and Aberdare corresponds closely in position with the nine-foot of the anthracitic region. The anthracitic region is regarded as commencing at the Vale of Neath, but there appears to be no definite boundary between it and the steam-coal area. Moreover, the anthracitisation is far from complete in the Vale of Neath, and continues to increase westwards beyond the limits of the map under description. Though all the seams are subject to the loss of bituminous matter in a west, or rather north-westward, direction, the lower seams are the first to show it. Thus, in any one vertical sinking the lower coals are on the whole less bituminous than the upper. The base of the Pennant is drawn arbitrarily at the Rhondda, No. 2 seam, which is known by another name west of the Neath. The measures in which the principal seams lie are illustrated in *vertical sections*—Sheet 83, Nos. 1, 2, 12, and 13; Sheet 84, Nos. 12, 13, and 19; and Sheet 85, Nos. 12–16.

The stratigraphy of the region is fully described, and further illustrated by a section from the Old Red Sandstone scarp to the Pennant scarp at Carn Mosyn (plate i). In addition to a large number of normal faults running in the N.N.W. direction—a system which prevails throughout the entire coalfield—there are two great belts of disturbances, known as the Cribarth and Neath disturbances, which traverse this region from E.N.E. to W.S.W. They form the forerunners of a long series of similar disturbances, which increase in frequency and intensity towards the north-west. All have exercised a marked control upon the river-system, a fact which is well illustrated in the relation of the Tawe and Neath Valleys to the two above-named disturbances. The sections across the Vale of Neath disturbance (plate ii) present an extremely effective piece of stratigraphy.

The glacial phenomena of the region constitute not the least interesting portion of this memoir. In previous parts, descriptive of the South Wales Coalfield, reference has been made to the importance of the Brecknock Fans in this connection. The fact that the Fans formed a centre of dispersion of boulders was first ascertained about 20 years ago by Professor Edgeworth David, and one result of the recent mapping has been to confirm his conclusions in all important particulars. It is shown that the ice generated on the Old Red Sandstone plateau moved in a general southward direction, surmounting the scarps of the Carboniferous Limestone and Millstone Grit, and crossing deep valleys with little or no deflection. It failed, however, to overtop the great Pennant scarp of Carn Mosyn, but split against it, one part moving down the Cynon and Taff Valleys in a direction somewhat east of south, while another part turned south-westwards down the valleys of the Neath and Tawe. Some morainic ridges, lying at the foot of the loftier precipices, appear to have been the last work of the retreating ice-sheet; several of these enclose tarns. The Brecknock drift, near its source on the Old Red Sandstone moorland, is composed wholly of the detritus of that rock. Being an unstratified deposit, with boulders but little rounded, it is classed as a Boulder-clay, but having been derived from a formation in which arenaceous material predominates it is of a gravelly character. Southwards, within the Carboniferous area, Carboniferous boulders enter largely into its composition, the quartz-conglomerates and grits of the Millstone Grit being especially ubiquitous. In the coalfield, where shales predominate, the deposit assumes the character of a typical Boulder-clay, and the red gravelly matrix gradually gives place to a stiff blue clay. These features are well illustrated by a map (fig. 12), showing the watersheds, distribution of the drifts, and the glacial striæ. The Brecknock drift and the local drift are distinguished by different symbols, and it is interesting to note how both classes of drift have been deposited in large amounts along the northern base of the Carn Mosyn massif, a portion hanging to the Neath drainage on the south-west and a smaller portion to the Taff drainage on the south-east.

III.—ROCK-MAGMAS AS SOLUTIONS.

DIE SILIKATSCHMELZLÖSUNGEN. I. UEBER DIE MINERALBILDUNG IN SILIKATSCHMELZLÖSUNGEN. II. UEBER DIE SCHMELZPUNKT-ERNIEDRIGUNG DER SILIKATSCHMELZLÖSUNGEN. By J. H. L. VOGT. Vidensk.-Selsk. Skrifter, 1903, No. 8, and 1904, No. 1.

THE analogy between igneous rock-magmas and saline solutions has been a subject of speculation since the time of Bunsen;

but it is only in comparatively recent years that the modern theory of solutions, as developed by Ostwald, Van t-Hoff, Nernst, Roozeboom, and others, has enabled the question to be treated in a precise manner. In his "British Petrography" (1888) Dr. Teall suggested that the lowering of melting-point in the mixture of two or more constituents might be applicable to rock-magmas, and that the order of crystallization of rock-forming minerals might depend upon the proportions in which they are present as compared with certain determinate (eutectic) proportions. He instanced micropegmatite as probably of the nature of a eutectic of felspar and quartz. The experimental data for putting the theory to the test were at that time lacking. They have now been in great measure supplied by Professor Vogt of Christiania. The starting-point of his work is the chemical and microscopical study of a large series of silicate-slags, more or less closely comparable in composition with igneous rocks. The results of such study, and the conclusions based on them, afford a striking illustration of the service which may be rendered to pure science by technological researches.

The first part of the memoir is essentially a comprehensive inquiry into the order of crystallization of minerals from magmas of known composition. Taking, for instance, slags consisting mainly of silicates of calcium, magnesium, and iron, without much alumina, the results are plotted on a diagram, ordinates representing acidity (i.e. the oxygen-ratio of silica to bases) and abscissæ representing the ratio *Ca* : *Mg*, *Fe*. Each slag corresponds thus with some point on the diagram, and the mineral which first crystallized out is noted (augite, enstatite, melilite, olivine, etc.). It is found that the points belonging to the several minerals arrange themselves in well-defined fields on the diagram. The boundaries (*Individualisationsgrenze*) between these fields represent eutectic proportions between the several constituents, and from them the percentage composition of the eutectics can be calculated. Thus, for augite and olivine the eutectic proportions are 70 : 30. From a molten slag consisting essentially of these two minerals in any other relative proportions, the one which is in excess, as compared with the eutectic, will first begin to separate.

In the second part of the memoir the lowering of melting-point in such mixtures is investigated, which gives another way of approaching the question. Here use is made of Akerman's determinations of total heat of fusion (in which the melting-point is the chief variable element); and the author has also made a series of experiments by the method of cooling, noting the temperatures at which latent heat is evolved. It is found that mixtures of two given minerals show a very notable lowering of melting-point, the greatest lowering being reached for certain definite relative proportions. These are, of course, the eutectic proportions; and the close agreement of the results with those already obtained independently by the 'individualisation' method afford a strong proof of the validity of the author's reasoning. The maximum lowering of melting-point is sometimes measured by hundreds of degrees.

Thus for olivine (melting-point 1400°), diopside (1225°), and åkermanite (1175°), the eutectic mixtures of the several pairs give melting-points—olivine-diopside 1125°, olivine-åkermanite 1030°, diopside-åkermanite 1035°; while for the ternary eutectic olivine-diopside-åkermanite the melting-point is well below 1000°.

The relations of minerals, such as quartz and the alkali-felspars, which are absent from slags, cannot, of course, be investigated by such methods; but it may be possible to obtain information in other ways. Vogt confirms Teall's view as to the significance of the micropegmatite intergrowth, and finds the eutectic proportions for felspar and quartz to be about 74 : 26. The figures seem to be very nearly the same in plutonic as in volcanic rocks; and theoretical considerations also lead to the conclusion that eutectic ratios are not greatly influenced by pressure.

An interesting branch of the inquiry is that relating to 'mixed crystals' belonging to isomorphous groups, in which the author applies the theoretical conclusions of Bakhuis Roozeboom. For mixtures of two isomorphous compounds the melting-point curve and the freezing-point curve are different. The crystals accordingly differ in composition from the magma in which they form, and they change their composition (or crystals of continually changing composition are deposited) as the process goes on. Several different types are distinguished. The author discusses especially the case of the plagioclase group, and shows why the first-formed crystals have a higher ratio *An* : *Ab* than the magma from which they are formed. He discusses also the interrupted series (imperfectly isomorphous or perhaps isodimorphous) of orthoclase-plagioclase, in which the only members which can exist are those near one or the other end of the series. Here there is a eutectic ratio 40 : 60. If the ratio *Or* : *Ab* + *An* is greater than this, orthoclase (containing more or less *Ab* and *An*) will first form; if the ratio is less, a plagioclase (with more or less *Or*) will form. If the magma eventually reaches the eutectic composition, orthoclase and plagioclase will separate out simultaneously; and the perthitic intergrowths are of this nature, with constant composition as regards the ratio of orthoclase to plagioclase. This part of the subject is very beautifully worked out from Lagorio's analyses of porphyritic felspars and the magmas from which they crystallized.

As regards the principal constituents of igneous rocks Professor Vogt's work seems to give a final answer to the vexed question of 'order of consolidation.' There remain the minor accessory minerals, which in general crystallize at a very early stage, although they are present only in small amount. It seems impossible to account for this behaviour by reference to eutectic proportions. Our author explains it by Nernst's law of the reduction of solubility by a common ion. This, which is a corollary of the law of mass action, tells us that spinel, for example, which has one ion (*Mg*) in common with other constituents of the magma, has its solubility thereby reduced, and consequently crystallizes earlier. It would be satisfactory to know more exactly in what measure this principle is operative, and how far it may affect the mutual relations of other minerals—olivine, enstatite, augite, and biotite all having this same ion in common. Any quantitative estimate, depending on the degree of electrolytic dissociation of the several constituents, will not easily be arrived at. The author will not allow that there may be only a *limited* mutual solubility between spinel, apatite, etc., and the silicates, though he finds this kind of relation between sulphides and silicates.

We can notice here only the main features of what is virtually the outline of a consistent theory of the crystallization of igneous rocks. Many other points are touched, sometimes comprehensively, sometimes sketchily, but always in a suggestive manner. They include, for example, the important consequences of supersaturation in the magma; the modifying influence of water and other so-called 'mineralisers,' and generally the question how far results derived from the study of slags are applicable to plutonic and other natural rocks; the application of the solution-theory to magmatic differentiation; and other petrological problems. The porphyritic structure, for instance, becomes from the author's point of view a general character, not necessarily implying a discontinuous change of physical conditions between two distinct 'periods of consolidation.' The porphyritic elements may represent the excess of one or more constituents separated out at an early stage, while the ground-mass tends often to an approximately eutectic composition. This hypothesis again is examined by the test of Lagorio's analyses.

We may hope that the outline presented by Professor Vogt will be filled in by the researches of himself and other petrologists. If modifications on some minor points should be found necessary, as well as additions, this will not lessen the debt which students of igneous rocks owe to the author of the valuable memoir before us.

A. H.

IV.—An Introduction to the Geology of Cape Colony. By A. W. Rogers, M.A., F.G.S., Director of the Geological Survey of Cape Colony. 8vo; pp. xviii and 463, with a folding map and 21 illustrations. (London: Longmans, Green, & Co., 1905. Price 9*s.* net.)

THE student of South African geology, after much time spent in reading numerous Government reports, treatises, and articles scattered through different magazines, at home and abroad, usually gives up the task in hopeless bewilderment, and ends with the conviction that "nothing is but what is not." He finally develops that fatal African disease known as the sleeping sickness, when all further interest in the subject naturally ceases. At what stage, if any, geologists in this country have arrived is a matter of conjecture and is hardly likely to be known. If such an unfortunate mortal exists good news awaits him. After reading the book by Mr. Rogers he will awaken like a giant refreshed.

The present volume is the first of a series designed by Dr. Muir, the Superintendent General of Education for the Colony of the Cape of Good Hope, to promote the study of Natural Science in South Africa, and with the consent of the Geological Commission the work was intrusted to Mr. A. W. Rogers.

The choice of author could not have been more happily made, for, in conjunction with Mr. E. H. L. Schwarz, Mr. Rogers has surveyed large tracts in the Colony during the past eight years, as well as making himself thoroughly acquainted with the literature of the subject.

The task submitted to Mr. Rogers was no easy one; but so skilful has been his performance of it that only those who have attempted to find light amidst the chaos of South African geology will realize its magnitude. Each of the many problems is adequately dealt with and yet kept in fitting proportion. The style is clear and concise, the natural result of a complete grasp of the subject. Simplicity of language, modesty of statement, adherence to fact, characterise the whole work. The descriptions are necessarily brief, but they are sufficient; there is no burdensome detail such as German writers on African geology abound in. The work of others, including that of his colleagues, receives due recognition; but the major portion of the volume really represents the results obtained by the field staff (three in number) of the Cape Geological Commission, of which Mr. Rogers is the oldest member.

The book will be found useful to many classes of readers. To those wholly ignorant of South African geology it will form a pleasing introduction; to the student, lost in the maze of conflicting accounts, it will tell what to follow and what to avoid; while the specialist, in almost every branch of geology, will find new material to illustrate and amplify the particular line of research on which he may be engaged.

In the opening chapter the author describes the chief physical features of the colony, its general geological outlines, order of the rock groups, followed by a brief but clear account of the regions occupied by the various rock formations and their tectonic relationship.

The rocks of pre-Cape age are dealt with in chapters ii–iii. The reader will here find a summary of the work done among these old rocks, the results being mainly obtained by the officers of the Cape Survey. They contain problems of a mineralogical, petrological, stratigraphical, and dynamical character, many of them of worldwide interest, and of especial importance in connexion with the age and succession of the older rocks of other parts of South Africa. Wisely enough, however, the author makes no attempt to force a correlation, either between the two areas in which this complex of rocks occurs in Cape Colony or with the far distant region of the Transvaal. We are pleased to see references to, and ample recognition of, the admirable researches of G. W. Stow in Griqualand West.

The question of the order of the succession of the different members of the Cape System (Table Mountain Sandstone, Bokkeveld, and Witteberg Series) and their relationship to the pre-Cape rocks is discussed, in conjunction with a description of the rocks, in chapter iv.

The classification of A. G. Bain is adhered to. The figures of fossils from the Bokkeveld beds are a welcome addition.

The Karroo formation, forming unquestionably one of the best known rock groups in South Africa, receives full attention. It is somewhat startling to read that at present there is no very satisfactory classification of these rocks. The chapter by Professor Groom on the reptiles of the Karroo formation will therefore be of much value, for, as is well known, these animals mark distinct horizons. As is fitting, considerable attention is paid to the intrusive dolerites and allied rocks of the Karroo system, for besides being a distinctive feature of the Karroo country they present problems the petrologist has not solved. The author does not support the absorption theory for the intrusive masses of Pondoland and East Griqualand. Plate xvi, showing columnar structure in Dwyka conglomerate produced by an overlying sheet of dolerite, might readily be used to controvert the knowing.

The knowledge of the rocks of the Cretaceous system is brought up to date in chapter viii. Good illustrations of the typical fossils are given, while Dr. F. L. Kitchin supplies notes on the relationship of the marine fossils to those of foreign Cretaceous faunas. The chapter on the volcanic pipes younger than the Stormberg Series (summit of the Karroo) includes a short account of the diamond pipes of the Kimberley area. The author considers that these great explosions occurred "at some period after the close of Stormberg times (probably after the Uitenhage period)."

A chapter on the Recent deposits, including that of the vleys and pans, concludes the detailed description of the geology. It is followed by a summary of the geological history of the colony. Subjects of a more speculative character are here dealt with, among which we note that the period of great mountain-building in South Africa succeeded the Ecca beds (Permo-Carboniferous) and occurred somewhere between this and the Uitenhage (Lower Cretaceous) period, possibly between the Ecca and Beaufort (Permo-Triassic) periods.[1]

Each of the chapters forms a treatise in itself, and the reader interested in any particular formation will readily find what he seeks, while for fuller detail he is referred to the standard works given in the appendix.

The volume is illustrated throughout by numerous plates of admirably reproduced photographs of rock scenery and rock structure. The figures of fossils are clearly drawn. The horizontal sections are somewhat meagre and not impressive, owing to the necessarily small scale adopted for the vast distances represented. On the coloured geological map, which is clearly printed, the number of place-names is far too small. A few topographical maps would materially assist the reader. The notes on the geology of some of the railway lines given in chapter xii seem out of character with the rest of the work, and would be better as an appendix. The book needs a more copious index.

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[1] Age given in the brackets is ours.

Some critics will probably find fault with the comparatively brief notices given of economic products. In a country of which the geology is so little known nearly the whole book becomes of economic importance. The geology of Cape Colony affords the key to the rock structure of South Africa, and therefore to its mineral wealth. Every engineer, miner, or prospector in South Africa, and those being trained in this country for the colony, should therefore make themselves fully acquainted with the main facts contained in this book, and thoroughly master the many problems so ably and clearly presented by Mr. Rogers. WALCOT GIBSON.

REPORTS AND PROCEEDINGS.

I.—GEOLOGICAL SOCIETY OF LONDON.

February 1st, 1905.—J. E. Marr, Sc.D., F.R.S., President, in the Chair.

Professor Garwood exhibited and commented on a set of twelve lantern-slides illustrating the use of three-colour photography in demonstrating the microscopic characters of rock-forming minerals in polarized light. The slides were taken by the Sanger-Shepherd process, in which yellow, green, and red screens were used. He said that it was not a process that could be used very easily, but one which required a good deal of time to produce really accurate prints. Considerable difficulty was experienced in procuring objectives which were truly corrected for the spectrum, the tendency in the case of interference figures being to give different-sized rings for different colours. The results did resemble very closely the phenomena seen under the microscope; and he had brought one or two rock-sections shown on the screen, in case Fellows interested in the subject would like to compare the slides with the original sections.

The following communication was read:—

"On the Sporangium-like Organs of *Glossopteris Browniana*, Brongn." By E. A. Newell Arber, M.A., F.L.S., F.G.S.

It has been discovered that some specimens from New South Wales, on which numerous and well-preserved scale-fronds of *Glossopteris* occur, also exhibit impressions of groups of minute bodies, not unlike the sporangia of certain recent and extinct Ferns and Cycads. The new organs are elliptical in shape, and measure from 1·2 to 1·5 millimetres along the major axis. They are hollow, sac-like structures, which open or dehisce longitudinally. Unfortunately no trustworthy evidence can be obtained as to their contents. The fact that they have never been found, except in the closest association with the scale-leaves of *Glossopteris*, is regarded as an indication that they may be attributed to that genus; and this conclusion is supported by the direct evidence of some of the scale-fronds, which show scars of attachment and fragments of the sac-like bodies still apparently in continuity. While, in the absence of recognition of spores, it is impossible to be quite certain that these sac-like bodies are really sporangia, there is much to be said in favour of this conclusion. The fact that they were probably borne on the scale-fronds in sorus-like groups, and that in size, shape, and mode of dehiscence they are not unlike the sporangia of certain recent and fossil plants, supports this view. The closest analogy may probably be found in the microsporangia of Cycads, which are also exannulate.

A historical sketch is given of the present evidence on the subject of the fructification of *Glossopteris*; and it is shown that no sporangia have so far been found, and that such evidence as has been put forward as to the occurrence of sori on the larger fronds is not altogether satisfactory. It is pointed out that, if the present conclusion be correct (that the sporangia were borne on the smaller scale-fronds), *Glossopteris* cannot be included in any recent family of the true Ferns. Although the affinities of this genus are still doubtful, the creation of a new family may not be inadvisable.

II.—EDINBURGH GEOLOGICAL SOCIETY.

January 18th, 1905.—James Currie, M.A., F.R.S.E., President of the Society, in the Chair.

The following papers were read:—

1. "Notes on a Journey through British North Borneo." By Mr. Andrew Burt.

Mr. Burt gave a sketch of a journey he had made through North Borneo, and described its position, climate, and products. He spoke chiefly of the coal-mines in Labuan and Sarawak, which, he explained, had to be worked by Chinese and Malay labour, the natives being practically useless as workmen.

2. "Notes on the Pre-Glacial River System of the Forth." By Mr. H. M. Cadell, B.Sc., F.R.S.E.

Mr. Cadell described various places where ancient buried river valleys had been proved by mining to exist at considerable depths below the present surface, and said it was highly important from a mining as well as a geological standpoint to be able to locate these drift-filled gullies of ancient 'wash-outs.' There was a deep glen under the Carron Water, which entered the Forth at Grangemouth, at a depth of 270 feet below the sea; and another below the Almond, which had been traced northward from Mid-Calder for eight miles, and ran seawards under Dalmeny Park at a depth of more than 100 feet. Between Preston Island and Culross, again, there was under Torry Bay an ancient trough, which had been struck in the coal workings on Preston Island in 1811 at a depth of 46 fathoms. This was no doubt a part of the ancient Forth Valley in pre-Glacial times. The deepest of the buried valleys that had hitherto been discovered by boring was the ancient gorge or canyon of the Devon, which at Glenochil Distillery had been found by boring to be over 370 feet deep, and filled with mud, sand, and clay. These ancient valleys all proved that when they were scooped out by swift rivers the land was much higher than it is now. Mr. Cadell went on to discuss this conclusion, and he showed that if the gradient of the ancient Forth was 25 feet per mile, the glen must have been 1,000 feet deep at the Forth Bridge, and the North Sea bed was a great plain. He exhibited interesting panoramic sketches he had painted, showing what he imagined was the scenery of the Forth Valley at that period where the islands of the Firth were the tops of rocky pinnacles, and hairy elephants, bears, and wolves roamed through the forests of the pre-Glacial continent, before Britain was an island.

III.—MINERALOGICAL SOCIETY.

January 31st, 1905.—Professor H. A. Miers, F.R.S., President, in the Chair.

Mr. H. H. Thomas gave a detailed account of the crystallographic, optical, and chemical characters of epidote found in a vein in gneiss, near Barrisdale, Inverness-shire. A chemical analysis made by Dr. Pollard showed that the mineral contained a very low percentage of ferric oxide (6·81). In this respect it was similar to epidotes from Huntington, Mass., and the Zillerthal, and like them showed correspondingly low refractive and double refractive power and large optic axial angle, as compared with epidotes containing higher percentages of iron.—Mr. T. V. Barker communicated a preliminary note on the regular growth of crystals of one substance upon those of another. The observations of previous investigators were in general confirmed with regard to the growths of K I, K Br, K Cl, and $Na\ No_3$ upon mica, and of $Na\ No_3$ upon calcite. In all cases a clean surface is necessary. Attempts to get a regular deposition of $Na\ No_3$ upon other rhombohedral carbonates of the calcite group and upon dolomite were without any positive result, although the rhombohedral angle of some of them is much nearer to that of $Na\ No_3$ than is that of calcite. The topic axes, however, are in order of magnitude as follows: $Na\ No_3$, calcite, rhodochrosite, dolomite, chalybite, so that if the regular growth depend on the fitting together of similar structures the experiments point to the usefulness of the conception of topic axes. The author is continuing his observations.—Mr. K. A. K. Hallowes described an apparatus for determining the density of small grains. The method is by hydrostatic weighing, and the grain is held under water (or preferably alcohol) in a spring-clamp, made of brass wire and two cover-glasses, which is suspended from the beam of the balance by a fine hair.—Professor H. A. Miers exhibited a specimen of massive danalite from Wheal Maudlin, a new locality for this mineral in Cornwall, and also a crystal of barium-radium bromide, the crystallographic characters of which he also described. Mr. Arthur Russell exhibited a specimen of phenacite and one of aurichalcite from Cornish localities, and Mr. H. F. Collins specimens of sulphide of lead and oxide of zinc artificially produced in furnaces at Laurium.

CORRESPONDENCE.

'DEUTOZOIC.'

Sir, — I can extract no other meaning from Mr. Goodchild's defence of the term 'Deutozoic' than this: that when next I am in a geological difficulty—say, about the age of the earth—I should refer the question to any eminent Professor of Theology, and submit to his decision. T. G. Bonney.

CREEP-FOLDING IN VALLEY BOTTOMS.

Sir,—When I read in "*Water*," vol. vi, p. 491, an account of a paper by Professor Boyd Dawkins dealing with the effect of relaxation of pressure in causing folds in the rocks at the bottom of valleys I thought I had come across what was no more than a reporter's error, repeated in the Geological Magazine, December, 1904, p. 618. Since, however, an almost identical statement appears in the Proceedings of the Manchester Lit. and Phil. Soc., vol. xlix, p. 8, I presume that it correctly represents Professor Dawkins's views on the subject.

The folding in the strata at the bottom of the Don and Derwent Valleys is held by the author to be "analogous in every particular" to 'creep' in coal-workings; and he goes on to say: "This may be studied in any coal-pit where there is a superincumbent pressure, say, of more than 1,000 feet." Now, the maximum pressure available at the Howden and Derwent dams is due to no more than 900 feet; moreover, this maximum pressure is only reached at a distance of 1½ miles from the valley, and is increasingly reduced as the latter is approached.

It cannot be contended that the removal of "at least 9,700 feet" of rock from above the site of the dams has had anything to do with the folding in the valley bottom, and yet it is difficult to see for what other purpose these figures are introduced except to lend support to the theory.

There is not the slightest evidence to show that the Derwent Valley was ever deeper than it is now; but if Professor Dawkins's figures mean anything they imply *a valley* 9,700 *feet deep with the stream on its present bed.* J. Allen Howe.

Museum of Practical Geology,
London.

OBITUARY.

PROFESSOR JOSEPH P. O'REILLY, C.E., M.R.I.A.

Born July 11, 1829. Died January 6, 1905.

By the death of Joseph P. O'Reilly, lately Professor of Mining and Mineralogy at the Royal College of Science, Dublin, yet another link with the older generation of Irish geologists and archæologists has been severed, as also the ties of friendship which existed between him and all those who came in contact with his charming personality. To none will the news of his death come with greater feelings of regret, than to his former pupils, amongst whom the writer is glad to be able to number himself.

As a teacher, Professor O'Reilly possessed the comparatively rare distinction of being able to make lectures on Mineralogy interesting, as well as instructive. A strong advocate of the use of the blackboard for demonstration purposes, he largely availed himself of this method of teaching, for which indeed his really fine draughtsmanship eminently fitted him. The beautiful perspective representations of the more complicated crystal forms, which he drew with surprising rapidity and accuracy on the blackboard, are not likely to be ever forgotten by those who, under his ægis, were first introduced to the science of crystallography. His concern for his students did not end with the lectures; he took a personal and kindly interest in each, and was ever ready with his help and advice both during and after their college career.

The fifth son of the late Thomas Reilly, Taxing Master in Chancery in Dublin, Professor O'Reilly was born in the town of Monaghan in 1829. Owing to the absence of facilities in Ireland, at that time, for learning the science of civil engineering, he went to Paris and studied for some years, at the Ecole Centrale des Arts et Manufactures, obtaining the Engineering diploma of that institution in 1855, and incidentally getting his first instruction in geology and mineralogy.

In 1856, he obtained the appointment of engineer to a French mining company, then engaged in exploiting the newly discovered zinc-mines of Santander in Spain. Later he was engaged by a second French company, who were working the deposits of sulphate of soda in the Jarama valley near Madrid. Returning to Ireland in 1863, he published the results of his geological investigations in the foregoing districts, in a series of papers written in conjunction with the late Dr. W. K. Sullivan. He became subsequently connected with the Mining Company of Ireland, at the time when the Silvermines district in Tipperary was being extensively worked. In 1868 he was appointed Professor of Mining and Mineralogy at the Royal College of Science for Ireland, a position which he held till the year 1899. In addition he held the post of Secretary in the same college from 1881 to 1894. He was also President of the Royal Geological Society of Ireland, in the year 1885; Vice-President of the Royal Irish Academy from 1886 to 1889, and again from 1901 to 1904; and acted as extern examiner in geology to the Royal University of Ireland, for several years.

His published contributions to the literature of Irish geology, mineralogy, and archæology were very numerous, altogether some sixty in number. A full bibliography will be given in the *Irish Naturalist* for March, and hence they need not be individually mentioned here. His geological papers dealt mainly with earthquakes and volcanic phenomena, and also with rock-joints, and their influence on the direction of coastlines. These papers, which were usually voluminous, betray an immense amount of painstaking work, such as few would care to undertake. As an instance, his catalogue of British and European earthquakes, which covers some 250 quarto pages, in the Transactions of the Royal Irish Academy (vol. xxviii) may be mentioned. After retiring from his professorship in 1899, his papers were mainly on archæological subjects, and were chiefly descriptive of some of the older ecclesiastical remains in the neighbourhood of Dublin.

Since the year just mentioned, no less than ten papers were written and published by him; he was, in fact, working up to and actually on the very day of his death, which took place suddenly on the evening of the 6th of January of the present year.

Henry J. Seymour.

THOMAS WILLIAM SHORE, F.G.S.

Born April 15, 1840. Died January 15, 1905.

We regret to record the death of Mr. T. W. Shore, who for many years was Curator of the Hartley Institution at Southampton, and one of the founders and Organising Secretary of the Hampshire Field Club. Mr. Shore was much interested in local geology and archæology, and was one of the secretaries of Section C of the British Association at the Southampton meeting in 1882, for which meeting he prepared the local guide.

He was the author of articles on "The New Dock Excavation at Southampton," with J. W. Elwes (1889), "The Clays of Hampshire and their Economic Uses" (1890), "Springs and Streams of Hampshire" (1891), "Hampshire Mudlands and other Alluvia" (1893), "Hampshire Valleys and Waterways" (1895); all published in the Papers of the Hampshire Field Club.

On retiring from the Hartley Institution, he settled at Balham, near London, and devoted himself more especially to antiquarian work. He assisted in founding the Balham Antiquarian Society, of which he was Secretary, and he was also Secretary of the London and Middlesex Archæological Society.[1]

PROFESSOR GEORGE BOND HOWES, LL.D., F.R.S.

Born September 7, 1853. Died February 4, 1905.

Biological science has sustained a heavy loss by the death of Professor G. B. Howes, whose high scientific attainments, coupled with an exceeding amiability of character and ever ready disposition to assist those who needed his help in their work, had endeared him to a wide circle of friends and students.

George Bond Howes was born in London in 1853; he was the eldest son of the late Thomas Johnson Howes, and was educated at a private school. He entered the Biological division of the Royal School of Mines in 1874 under Professor Huxley. In 1881 he was made Demonstrator in Biology in the Normal School of Science, and in 1885 Assistant-Professor. Professor Huxley in that year was compelled by ill-health to resign all his public offices, only retaining his connection with the Normal School of Science and Royal School of Mines as Dean and honorary Professor of Biology. On Professor Huxley's death in 1895, Dr. Howes was appointed his successor as Professor of Zoology. He was formerly Lecturer on Comparative Anatomy to St. George's Hospital Medical School, and for several years was one of the Examiners in Biology to the University of London; a Vice-President and member of Council of the Zoological Society of London; Hon. Zoological Secretary Linnean Society; ex-President of the Malacological Society; and President of Section D, British Association in 1903. Dr. Howes was widely known by his "Atlas of Practical Elementary Biology," and by his papers on the morphology and physiology of the Vertebrata, both recent and fossil. He was joint editor with Dr. D. H. Scott of a revised and extended edition of Huxley & Martin's "Course of Practical Instruction in Elementary Biology."

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[1] We are indebted for some of the above particulars to the *Times*, Jan. 17, 1905.

His death at the comparatively early age of 51 years was doubtless accelerated by a combination of unfortunate accidents, which acting upon a highly nervous organisation proved too severe for his delicate constitution to sustain. He leaves a wife and daughter to deplore his loss.

MISCELLANEOUS.

Dover Coal-boring.—It is satisfactory to learn that "At last the dogged perseverance of those who direct the policy of the Consolidated Kent Collieries Corporation (Limited), on whose shoulders have fallen the mantles of several Kentish coal companies, has been rewarded, and a workable seam of bituminous coal, one foot eight inches thick, has been 'struck.'" We quote these words from the *Morning Post* of February 4th. It will be remembered that a boring at Dover in search of coal was commenced in 1886, and the discovery of coal was announced in 1890. The present record of "'Black Diamonds' at last" is simply the confirmation of the evidence obtained in the original boring by the sinking of a shaft through the same series of strata to a depth of 1274 ft. 10 ins. A coal-seam found in the original boring carried out by Mr. F. Brady has now been struck in the shaft at practically the same level, and about 12 tons of good coal have been raised. It is stated that a second shaft must be sunk before the coal can be worked. There is a second shaft which is over 600 feet deep, but it is calculated that at least two years must elapse from the time the plant has been secured before this shaft can be completed. Meanwhile the present shaft must be sunk more than 500 feet deeper to reach other seams proved in the original boring. From a geological point of view the prospect is encouraging.

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ORIGINAL ARTICLES.

I.—Devonian Fossils from the Parish of St. Minver, North Cornwall.

By Howard Fox, F.G.S.

I CONTRIBUTED a paper to the April number of the Geological Magazine for 1900 on the geology and fossils of the Devonian rocks on the north coast of Cornwall, *south* of the River Camel. In the present communication I propose to notice a series of fossils which I have lately obtained from the slaty rocks of Devonian age in the parish of St. Minver on the *north* of the Camel, which, from Trewornan, one mile north of Wadebridge, for the lower five miles of its course as river and estuary, forms the southern and south-western boundary of this parish. The open sea-coast forms its northern and north-western boundary, extending from the easterly limit at the Cove of Port Quin, the site of an old but now forsaken fishing village, about eight miles south-west of King Arthur's Castle, Tintagel, westwards round the basaltic cliffs of Pentire Head, and thence in a southerly direction to the estuary of the Camel.

The fossils generally occur partially weathered out on the surface of the slates of the low cliffs and beaches along the coastline and estuary. We propose first to refer to the principal localities where they have been obtained, beginning at Port Quin and following the northern and western coastline to the estuary, and then eastward, along the southern boundary to Trewornan. The names of the places mentioned will be found on the 6 inch maps of the Ordnance Survey.

The first locality west of Port Quin where fossils have been found is at the small cove of Epphaven, about a mile distant. In bluish slates at this place a fragmentary Ophiurid (Brittle-star) was obtained by Miss Barbara Legg in 1902. The specimen has been described and figured by Dr. Bather under the name of *Sympterura Minveri*, n. g. et sp., in the accompanying paper. The same slates also contain detached crinoidal stem-joints and minute spine-like bodies referred to *Styliola*.

To the west of Com Head, in slaty boulders on the beach and in the cliffs, small branching corals, belonging to *Pachypora*, and crinoidal fragments are occasionally met with.

On the south side of Pentire Point, and immediately west of Pentire Haven, there are several caves, floored with bright shingle, known as the 'Gravel Caverns.' Seaward of these caves there are three large masses of conglomerate conspicuous from the bright pebbles of which they are largely composed, and beyond these seawards several beds of the same kind of rock may be seen when storms have partially removed the loose beach material which usually covers them. Another bed of this rock is also visible, forming a ledge at the base of the cliff north of the Gravel Caverns towards Pentire Point. The conglomerates, and the slates in contact with them, contain fragments of fossil wood, branching coral, *Pachypora* sp., crinoidal joints, *Cardiola retrostriata*, *Orthoceras* or *Bactrites*, and small Goniatites. The molluscan remains are usually pyritized.

From Pentire Haven we pass southward for some miles, coasting the cliffs of Pentire Glaze Haven, Polzeath, Trebetheric Point, and Daymer Bay, till we reach the igneous rocks of Bray Hill. The cliffs are composed of beautifully banded, purple, green, grey, and buff slates which De la Beche[1] classed in error with the variegated Lower Devonian slates of Watergate Bay, further to the south. No fossils have as yet been met with in these northern variegated slates.

The village of Rock, to which the ferry-boat from Padstow plies, is at the northern boundary of a range of shore-line which extends in a south-easterly and easterly direction, forming the north bank of the Camel, as far as Trewornan at the eastern corner of St. Minver parish. Along this shore beds of slate, limestone, and various igneous rocks, including volcanic lavas and tuffs, are exposed. The slates are very strongly cleaved, so that it is difficult oftentimes to distinguish bedding and cleavage and to determine their strike. In places they are very fossiliferous, and not infrequently the fossils are in better preservation than those hitherto found in the rocks south of the Camel. This fossiliferous coast area may be considered more conveniently in the following divisions:—

1. *Porthilly Cove, i.e. from Rock to Porthilly Point.*

Some of the slates contain numerous specimens of minute *Styliola*, whilst in other slates of a blue or brown colour, in the neighbourhood of igneous rocks, cup-corals and crinoidal remains are present, but they are very poorly preserved.

2. *Porthilly Point to Gentle Jane or Cant Hill.*

In the low cliffs south of Porthilly Point there are black nodules containing fragments of *Conularia*, and beyond these, in a series of old slate quarries, cup-corals, crinoidal remains, *Styliola*, and casts of small doubtful Brachiopods or Lamellibranchs are present. Casts of *Pleurodictyum* are plentiful; on one loose slab of slate, 3 feet by 2¼ feet, four colonies were found; some of the specimens are in very fair preservation. Near the eastern end of this section, two small Trilobites were found in blue slates on the foreshore: they have been referred by Dr. H. Woodward to *Phacops latifrons.*

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[1] Report on the Geology of Cornwall, etc., p. 91.

3. *Gentle Jane or Cant Hill to Cant Cove.*

The beach at Gentle Jane, like most of those along these foreshores, is composed of worn fragments of blue slate, with hardly any admixture of quartz pebbles or sand. It is situated at the western end or foot of a long flat-topped hill, 247 feet in height, composed for the most part of volcanic lavas and tuffs (Schalstein). The slates of this range of shore become increasingly fossiliferous as the igneous rocks are approached. About 300 yards from Gentle Jane the slates are nodular and contain casts of Cephalopods, which are described by Mr. G. C. Crick in the annexed paper. They belong to *Orthoceras*, *Cophinoceras*, and *Agoniatites.*

To the east of the area characterized by the predominance of Cephalopods there are three exposures of igneous rock, and about 150 yards beyond the last of these there are some nodular grey, greenish, and buff slates, in which, with some Polyzoa and other fossils, a fair number of Trilobites belonging to the genus *Phacops* are present. Some of these are in good preservation, and retain the facetted structure of the eyes in fairly perfect condition.

Yet further eastwards the foreshore is covered to a varying extent with rounded fragments of lava and tuff similar, Mr. Ussher informs me, to the Schalstein of Drake's Island, Plymouth, and other localities in Cornwall and Devon. Some of the slates interbedded with the Schalstein are filled with fossils which are now for the most part decomposed to a bright red rust, and consequently in a very fragile condition.

This tract of foreshore included in the term of 'Cant Hill' is by far the most prolific in the area of St. Minver, both in the number and variety of its fossils, and in addition to the genera already mentioned as occurring in it the following are also represented: *Petraia*, *Zaphrentis*, *Cyathophyllum*, *Amplexus*, *Favosites*, *Alveolites*, *Pleurodictyum*, *Monticulipora*, *Fenestella*, *Polypora*, *Phyllopora*, *Atrypa*, *Spirifer*, *Pentamerus*, *Rhynchonella*, *Orthothetes*, and *Conularia.* Crinoidal remains are also plentiful, but they cannot be assigned to any particular genus.

4. *Cant Cove to Dinham Creek.*

Rounding Cant Cove, we find on the shore to the east pale grey slates from which were obtained *Styliola*, *Polypora*, and a well-preserved and interesting small Trilobite, which Dr. H. Woodward has figured and referred to *Phacops granulatus*, Münster. A fairly perfect cast of an *Orthoceras*, figured and described by Mr. Crick as near to *O. hercynicum*, was also found in these slates. Crinoidal stem-joints are likewise common.

Igneous rocks are present on both sides of the entrance to Dinham Creek, whilst at the inner end of the creek, south of the bridge crossing the stream, there are several beds of limestone. These have been noted by De la Beche on the Survey Map.

5. *Dinham Creek to Treworнan.*

In this tract of the shore the only fossils met with are *Styliola*, the cast of a small Gasteropod, and several fragmentary specimens of *Orthoceras*, which have been referred by Mr. Crick to *O. nassoviense*, Foord, *O. gracile*, Blum., *O.* sp., intermediate between *O. rapæforme*, Roem., and *O. subconicum*, Roem., and a fragment of a *Bactrites*. The low cliffs extending for about half a mile to Trewornan are composed of variegated unfossiliferous slates similar to those in the cliffs between Pentire Haven and Rock.

LIST OF FOSSILS FROM ST. MINVER.

Hitherto no list of the fossils from this particular area appears to have been published, and it seemed therefore desirable to prepare one which would be of service in comparing with the fossil faunas from other parts of Cornwall, and also throw some light on the particular horizon of the Devonian series to which they may be referred. Not having the special knowledge or the requisite opportunities for determining the fossils myself, I have again had recourse to the assistance of my palæontological friends who have helped me in past years, and desire here to express my great obligations to Dr. H. Woodward, F.R.S., who has described the Trilobites, to Mr. G. C. Crick, F.G.S., for the determination of the Cephalopods, to Dr. F. A. Bather, F.G.S., for the description of the new Ophiurid, to Dr. C. A. Matley, F.G.S., who had examined the Brachiopoda, and to Dr. G. J. Hinde, F.R.S., for the list of the Corals and Polyzoa.

ACTINOZOA.

Petraia spp. Casts of small cup-corals, probably representing two or more species. Common at Cant Hill, east of Cant Cove.

Zaphrentis sp. Depressed conical, at summit 20 mm. wide, 20 principal septa, well-marked fossula. Cant Hill.

Amplexus (?) sp. Compound, branching, the branches diverge from a common stock, about 10–15 mm. in diameter and about 150 mm. in length. Septa about 40, their interior characters not shown. Cant Hill.

Cyathophyllum sp. Cylindrical, 5–6 mm. in diameter, about 36 septa. Cant Hill. Rare.

Favosites sp. A small fragment on a slab with *Atrypa reticularis*. Cant Hill.

Alveolites sp. Plate-like growths, some measuring 70 mm. by 50 mm., walls replaced by rusty material, corallites about 0·5 mm. in width. Cant Hill. Common.

Pachypora sp. Branching form, the branches about 5 mm. in diameter, and the corallites about 0·5 mm. wide. West of Com Head.

Pachypora, sp. *a*. Fragment of a branching specimen, the branches 10 mm. in diameter, corallites round or oval, 0·8 mm. wide. Gravel cavern conglomerate, south of Pentire Point.

Pleurodictyum sp. The same forms as those from Constantine Bay, Porthcothan Cove, and other localities, described in GEOL. MAG., Dec. IV, Vol. VII (1900), p. 151, Pl. VII, Fig. 11. East of Porthilly and Cant Hill. Common.

OPHIURIDEA AND CRINOIDEA.

Sympterura Minveri, Bather. (See accompanying paper.) Epphaven.

Crinoidea. Stem-joints, usually as casts. Epphaven; west of Com Head; south of Pentire Head, in conglomerate; Porthilly Cove; south of Porthilly Point; Cant Hill; east of Cant Cove. Common.

TRILOBITA.

Described by Dr. H. Woodward. (See accompanying paper.)

Phacops latifrons, Bronn. Cant Hill. Common.
„ *granulatus*, Münster. Cant Hill; east of Cant Cove. Common.
„ (*Cryphæus*) *punctatus*, Steininger. Cant Hill.
„ (*Trimerocephalus*) *lævis* (?), Münster. Cant Hill.

POLYZOA.

Monticulipora (*Monotrypa*) sp. A small fragment, encrusting, cells about 0·25 mm. broad. Cant Hill.

Fenestella, sp. *a*. Polyzoary fan-shaped, branches straight, closely set, 0·5 mm. in width, fenestrules oval, 0·5 mm. in length, 2–3 zoœcia between each dissepiment, apertures prominent and thickened. Cant Hill.

Fenestella, sp. *b*. Only a small part of the upper face shown. Branches narrow, 0·3 mm. in width, keel prominent, fenestrules subangular, about 0·8 mm. in length, 2–3 cells between each dissepiment. Cant Hill.

Polypora sp. Fragment. Branches 0·5–0·7 mm. broad, fenestrules oval, 1 mm. long by 0·5 mm. wide, 3–4 rows of cells. East of Cant Cove.

Phyllopora sp. Fragment. Branches inosculating, 0·5–0·8 mm. in width, 3–4 rows of cells, alternating, fenestrules elongate, irregular. Cant Hill.

BRACHIOPODA.

The Brachiopods have been kindly examined by Dr. C. A. Matley, who reports that, owing to the fact that many of the specimens are only casts and these often crushed and distorted, their exact identification is very difficult, and the names given to them should, therefore, with some exceptions, be considered as approximations rather than certainties.

Orthothetes crenistria (?), Phill. Fragments only. Cant Hill.

Orthothetes (?). Cast of interior; the characters are peculiar, and the genus cannot satisfactorily be defined. Cant Hill.

Atrypa reticularis, Linn. A single specimen, well preserved. Cant Hill.

Atrypa cf. *desquamata*, Sowerby. Dr. Matley states: "I am doubtful, as there are some peculiar ridges in the interior of both valves (shown in the internal casts), which I have not met with before in this genus." This is the commonest form; ten specimens were obtained, the majority are casts. Cant Hill.

Spirifer sp. The nearest species to this seems to be *S. cultrijugata*, Roemer, but this appears to be quite distinct. Cant Hill.

Spirifer sp., cf. *S. speciosa*, Schl. A single specimen. Cant Hill.

Pentamerus (? *Gypidula*) *brevirostris*, Phill. An internal cast. Cant Hill.

Rhynchonella (*Camarotœchia*) *laticosta*, Phill., ? var. There are only 4 ribs on the fold. An internal cast. Cant Hill.

LAMELLIBRANCHIATA.

Cardiola retrostriata, Von Buch. Pyritised casts. Gravel conglomerate. South of Pentire Point.

PTEROPODA.

Styliola sp. Epphaven, Porthilly Cove, west and east of Dinham Creek.

Conularia subparallela, Sandberger. Cant Hill.

,, sp., cf. *C. deflexicosta*, Sandberger. Porthilly, Cant Hill.

CEPHALOPODA.

Described by Mr. G. C. Crick. (See accompanying paper.)

Orthoceras cf. *hercynicum*, Kayser. East of Cant Cove.

,, cf. *commutatum*, Giebel. Cant Hill.

,, *nassoviense*, Foord. East of Dinham Creek, Trewornan.

,, cf. *O. rapæforme*, Roem., and *O. subconicum*, Roem. East of Dinham Creek.

,, *gracile*, Blum. Trewornan.

,, or *Bactrites*. Conglomerate. Gravel Caverns, south of Pentire Point.

Bactrites sp. Trewornan.

Cophinoceras sp. Cant Hill.

Phragmoceras (?) sp. Cant Hill.

Tornoceras sp. Conglomerate. Gravel Caverns.

Agoniatites sp. Cant Hill.

Although the specific characters of many of the fossils in the above list cannot be recognized owing to their imperfect preservation, there appears to be sufficient evidence to justify the conclusion that, whilst the Gravel Caverns conglomerate and the slate rocks forming the banks of the north shore of the Camel estuary in the Porthilly and Dinham Creek districts are Upper Devonian, those in the intermediate and more southern region of Cant Hill may be Middle Devonian in age.

II.—NOTES ON A SERIES OF TRILOBITES OBTAINED BY MR. HOWARD FOX, F.G.S., FROM THE DEVONIAN OF CANT HILL, ST. MINVER, CORNWALL.

By HENRY WOODWARD, LL.D., F.R.S., F.G.S.

(PLATE V, FIGS. 1–6.)

IN September of last year I received from Mr. Howard Fox, F.G.S., of Falmouth, nine specimens of Trilobites for the purpose of determination and description. They are all more or less fragmentary, and distorted by slaty cleavage, as is usually the case with fossils from these Devonian Slates of Cornwall and Devon, reminding one of the distorted Trilobites and Starfishes from the Lower Devonian Slates of Bundenbach, Germany.

I subjoin a list of the specimens received and my notes thereon, which I hope may prove acceptable to my friends in Cornwall.

1.	*Phacops*	*latifrons*,	Bronn:	Cant Hill,	St. Minver,	North Cornwall.
2.	„	(*latifrons* ?)	„	„	„	„
3*a*, *b*.	„	*granulatus*,	Münster:	east of Cant Cove,	north shore,	North Cornwall.
4.	„	„	„	Cant Hill,	St. Minver,	„
5.	„	„		„	„	„
6.	„	(*latifrons* ?)		„	„	„
7.	„	*punctatus*,	Steininger:	„	„	„
8.	„	*lævis* (?),	Münster:	„	„	„
9.	„	*latifrons*,	Bronn:	„	„	„

1. PHACOPS LATIFRONS, Bronn. (Plate V, Figs. 1*a*, 1*b*, 2 ?)

Calymene latifrons, Bronn, 1825: Leonhard's Zeitschr. f. d. Mineral., p. 317, t. ii, figs. 1–8.

Phacops latifrons, Sandberger, 1850: Verstein. Rheinisch. Schichtensyst. Nassau, t. i, fig. 7.

Phacops latifrons, Salter, 1864: Mon. Pal. Soc., pt. i, p. 18, pl. i, figs. 9–16.

I have referred Nos. 1, 2, 6, and 9 of Mr. Howard Fox's specimens to *Phacops latifrons*, Bronn, which is one of the most characteristic forms of Devonian Trilobites, and is recorded by writers on this formation from Cornwall, Devon, the Eifel, in Germany, and elsewhere.

No. 1 is a rolled up and very much compressed specimen drawn on Pl. V, Fig. 1*a*, in profile; the same specimen being also shown from the underside in Fig. 1*b*. Fig. 1*a* exhibits the right cheek or glabella, and the large compound eye, which is very prominent in this species. The surface of the glabella (which in *P. latifrons* is covered with coarse tubercles) is completely obliterated in this specimen by the compression which the fossil has undergone in the matrix. The angle of the cheek is bluntly rounded off and not produced into a genal spine, the border is rounded and slightly elevated. The visual surface of the eye forms a raised crescent, 9 mm. above the cheek border, with a length of 18 mm. along its outer curved surface. It shows upwards of twelve rows of facets, each row having from five to six distinct prominent rounded lenses upon its surface. The compressed body and head are 35 mm. in thickness and 50 mm. long in profile in their present folded up state.

Fig. 1*b* shows the flattened out thoracico-abdominal segments and a part of the pygidium seen from below. The most anterior segments are seen in the profile view, where they unite with the head-shield (Fig. 1*a*); the others in Fig. 1*b*. About ten or eleven free segments can be counted altogether. The ends of the pleuræ are recurved and rounded. A part of the pygidium is exposed, but the rest is buried in the matrix. There is a trace of a single row of three or four tubercles upon the axis of some of the free thoracic segments. The body-segments are 58 mm. broad by 51 mm. long.

No. 2 specimen (see Pl. V, Fig. 2) consists of a pygidium accompanied by five or six displaced thoracic segments. The pygidium is much flattened. It measures 52 mm. in breadth by 36 mm. in length. The axis is composed of about ten or eleven coalesced segments, and is 14 mm. broad at the proximal end (where it united with the free body segments), diminishing to 6 mm. near the blunted free border, which is quite flattened out by pressure. Indications of about six coalesced pleuræ mark the lateral portion of the pygidium; the axis and pleuræ are sparsely ornamented by a single row of small tubercles on each segment. The general rounded form of the pygidium is marred by the extreme compression to which it has been subjected.

On No. 6 (marked doubtfully as *Ph. latifrons*?) are two badly-preserved specimens of Trilobites, each showing the head and body rings on the edges of the cleavage-planes (which are stronger than those of the original bedding); both specimens are stained red with peroxide of iron. Except in general resemblance, they are too obscure for accurate determination. Locality as before stated, Cant Hill, St. Minver.

No. 9 exhibits parts of several obscure organisms, preserved on the surface of a small slab, some of which appear to be crinoidal, but one is the eye of a Trilobite, and may be referred to *Ph. latifrons*. This species is recorded from the Lower Devonian, Hope and Barton, South Devon; near Liskeard and Totnes in slates with *Pleurodictyum problematicum*. Middle Devonian, Newton Bushell; Upper Devonian, Barnstaple, Pilton, Yealm Bridge, Launceston. Mr. Howard Fox's specimens are labelled from Cant Hill, St. Minver, on the northern banks of the Camel Estuary.

2. PHACOPS GRANULATUS, Münster. (Plate V, Figs. 3, 4.)

Calymene granulata, Münster, 1842: Beiträge, Heft 5, t. v, fig. 3.
Calymene granulata, Phillips, 1841: Pal. Foss., fig. 248 (excl. figs. *m*, *n*, *o*, *p*).
Phacops granulatus, Salter, 1864: Mon. Pal. Soc., pt. i, p. 18, pl. i, figs. 1–4.

This species is recorded by Salter from the Upper Devonian of Petherwin, Cornwall. Although so small (Pl. V, Fig. 3) it is the best preserved and most interesting of Mr. Fox's specimens. It consists of an intaglio and relievo of a small Trilobite (represented twice the natural size in our Plate), measuring 24 mm. long by 12 mm. broad (originally broader, but compressed by slaty cleavage), and resting on the edges of the cleavage planes and parallel with them, which accounts for its having escaped even greater distortion.

McCoy originally described it in 1851 in his "Synopsis of Woodwardian Fossils," p. 177. Salter defines it as "General form broad-oval. Head semicircular, very convex, covered with granules. [Owing to the absence of the tests the ornaments of tubercles on the glabella cannot be seen in Mr. Fox's specimen, but traces of these can be detected in the intaglio.] The sides (cheeks) much bent downwards. Glabella fully half the width of the head, very tumid, slightly pointed in front, and overhanging the front margin. Its greatest width exceeds its length, even including the neck-segments; a small basal lobe, with a tubercle on each side, but no glabellal furrows visible. Cheeks moderate [genal border rounded posteriorly], with a strong border. Eyes large, prominent, with few, about thirty-six, lenses, five in a row" (after McCoy). We may add to this:—Thorax consisting of eleven well-defined free-segments; axis strongly arched, semi-cylindrical, with a deep furrow separating it from the pleuræ; pleuræ strongly recurved, rounded, and somewhat expanded at their extremities. Pygidium semicircular, small, convex, surface somewhat smooth, axis well marked, but divisions of pleuræ only faintly indicated.

Measurements: length of head 7 mm., of eye 4 mm., of thorax 12 mm., of pygidium 5 mm.; breadth of axis of body 3 mm. Mr. Howard Fox's original specimen is from east of Cant Cove, St. Minver.

No. 4. This specimen (Pl. V, Fig. 4) no doubt belongs also to the same species as No. 3. It gives a side view of another example, in which, however, the head is partially wanting, but the crushed glabella and the left eye can be detected.

Total length 24 mm. Head 6 mm. long; length of (11) thoracic segments 12 mm.; pygidium 6 mm. Breadth of exposed axis and left pleuræ 8 mm. (broadened by pressure). The form of the pleuræ with their rounded, recurved, and expanded extremities is well seen in Fig. 4. This specimen also comes from the Devonian of Cant Hill, St. Minver.

No. 5. This example is not figured. It is similar in condition to No. 4, but is *less* well preserved. All the thoracic segments seem present; the head, however, is wanting (or represented only by the projecting eye); the pygidium is also absent. Length 15 mm. Same locality as preceding specimen.

3. PHACOPS (CRYPHÆUS) PUNCTATUS, Steininger. (Pl. V, Fig. 5.)

Olenus punctatus, Steininger, 1833: Mém. Soc. Géol. Fr., vol. i, p. 356, pl. xxii.
Phacops punctatus, Salter, 1864: Mon. Pal. Soc., p. 59, pl. i, figs. 17–19 (and woodcut, p. 59).

This specimen is marked No. 7 in Mr. Howard Fox's collection, and like the others is from Cant Hill, St. Minver. It consists of the profile of a head of a trilobite showing the free-cheek and compound facetted eye. The margin of the free-cheek has a strong ridge along it, and, although so imperfect a fragment, I am inclined to refer it to ***Phacops punctatus***, Steininger. The surface of the shield is punctate, the head margin is produced in front of the glabella; the posterior angle of the free-cheek, though not complete, shows that it was originally prolonged backwards into a genal spine. Length of fragment 15 mm., length of visual surface of eye 5 mm.

Mr. Salter, in 1864, records imperfect specimens of this species as having been found in the Middle and Lower Devonian of Torquay, South Devon, and from the slates of Liskeard, Cornwall, and he remarks: "It is certain that a very beautiful Trilobite has yet to be found in Cornwall and S. Devon, and collectors should look carefully for it" (Pal. Soc. Mon., p. 60). We have now to add the locality of St. Minver.

No. 8 consists of an imperfect series of nine thoracic segments, and a trace of head and pygidium from Cant Hill. The free extremities of the pleuræ are less curved and less expanded than in *Ph. latifrons* or in *Ph. granulatus*, and the pygidium appears to be more narrow and elongated, but this may be due to distortion in the rock. I do not propose to determine this specimen specifically, but it may be a distorted fragment of *Phacops* (*Trimerocephalus*) *lævis*, which has been obtained both in North and South Devon and at Mudstone Bay, etc.

EXPLANATION OF FIGURES OF TRILOBITES ON PLATE V.

FIG. 1*a*.—Profile of *Phacops latifrons*, Bronn. Devonian: Cant Hill, St. Minver, Cornwall. × ½.

,, 1*b*.—Under side of same specimen. Nat. size.

,, 2.—*Ph. latifrons* (?). Pygidium. Devonian: Cant Hill, St. Minver, Cornwall. Nat. size.

,, 3.—*Ph. granulatus*, Münster. Profile of a nearly perfect specimen from same formation, east of Cant Cove, St. Minver. × 2.

,, 4.—*Ph. granulatus*, Münster. A less perfect specimen, showing thoracic segments, imperfect head and pygidium. Same formation, Cant Hill, St. Minver. × 2.

,, 5.—*Ph. punctatus*, Steininger. An imperfect cheek, with eye. × 2.

(For explanation of Figs. 6–8, Pl. V, see end of Mr. G. C. Crick's paper.)

III.—ON SOME FOSSIL CEPHALOPODA FROM NORTH CORNWALL COLLECTED BY MR. HOWARD FOX, F.G.S.

By G. C. CRICK, F.G.S., of the British Museum (Natural History).

(PLATE V, FIGS. 6–8.)

THE following descriptions are based upon fossils sent to me for determination by Mr. Howard Fox, F.G.S. Excepting the specimen which is compared with *Orthoceras hercynicum* and is marked "E. of Cant Cove," the fossils are from Cant Hill, St. Minver, N. Cornwall.

At the end of the descriptions are added notes upon some very imperfect fossils which Mr. Fox has collected from other localities in St. Minver.

ORTHOCERAS cf. HERCYNICUM, E. Kayser. (Pl. V, Figs. 6*a*, 6*b*.)

Orthoceras hercynicum, E. Kayser: Abhandl. zur geolog. Specialkarte v. Preussen, etc., Bd. ii, Heft 4 (1878), p. 72, pl. x, figs. 7, 8, 11; pl. xi, fig. 3 (?).

Among the specimens submitted to me by Mr. Howard Fox there are several examples of the genus *Orthoceras*. The most nearly perfect specimen is represented in Pl. V, Figs. 6*a*, 6*b*. It is a crushed internal cast about 200 mm. in length, of which the body-chamber occupies about 55 mm. The rate of tapering is about 1 in 5, the greatest width at the aperture being about 40 mm., and at the last septum about 28 mm. In its crushed condition the depth of the chambers is about one-third of their width. The siphuncle is slightly excentric (see Fig. 6*b*). Parallel to, and at about 8 mm. below the aperture on the side of the body-chamber opposite to that which is figured, there is a shallow constriction about 6 mm. wide. There are no remains of the test; the surface of the cast is smooth. The specimen, though evidently much compressed during fossilization, probably originally had an elliptical cross-section. The septa are rather oblique, but being nearly parallel to the aperture this obliquity may be due in great measure to crushing. On the whole the specimen seems to be comparable with such a form as *Orthoceras hercynicum*, described by Kayser from the limestone at Hasselfelde in the Hartz belonging to the lower part of the Middle Devonian, or with the form which Kayser figures and describes as *Orthoceras* sp. (op. cit., p. 72, pl. xi, fig. 1), from the same horizon and locality.

A septated fragment, about 45 mm. long, is possibly referable to this same species.

ORTHOCERAS cf. COMMUTATUM, C. G. Giebel.

(See Text-figures, p. 156, Figs. 1, 1*a*.)

Orthoceras commutatum, C. G. Giebel: Fauna der Vorwelt, Bd. iii (1852), p. 233.[1]

Another *Orthoceras* indicating a different species is represented in the accompanying figures (Figs. 1, 1*a*). It is flattened, slowly tapering, and about 92 mm. long; the ventro-dorsal and transverse diameters in its present crushed state being 25 and 51, and 23 and 40 mm. respectively. It consists of the internal casts of three chambers, and of part of a fourth, the anterior one being imperfect; the septa are about 21 mm. apart. The siphuncle is not clearly shown, but at the posterior end of the specimen there appears to be a faint indication in a slightly excentric position of something which may have been the siphuncle. There is also a depression at the anterior end, but this seems to be the impression of another organism. The surface of the cast is smooth; there are no traces of any sculpture. This specimen, characterized by its deep chambers and slowly tapering shell, appears to be related to the Devonian form which Kayser has figured (loc. cit., pl. x, figs. 1–3; pl. xi, figs. 4, 8) as *Orthoceras commutatum*, Giebel, and recorded from the limestone at

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[1] This is the species which was described as *Orthoceras longicameratum* by Foord (Cat. Foss. Ceph. Brit. Mus., pt. i, 1888, p. 80), but this name being preoccupied Foord altered it to *O. nassoviense* (ibid., Corrigenda and Addenda, p. xxxi). The species, however, is evidently the same as that for which Giebel had already proposed the name *O. commutatum*.

Hasselfelde in the Hartz, a locality which also yields the previously-mentioned species, *Orthoceras hercynicum*.

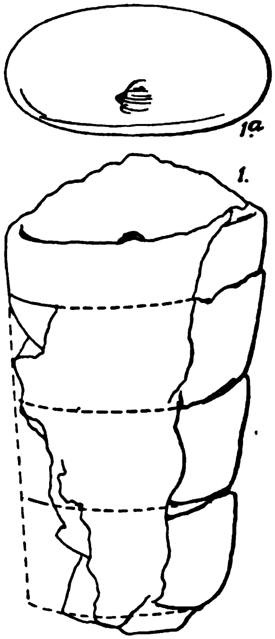

FIG. 1.—*Orthoceras* cf. *commutatum*, C. G. Giebel, showing internal casts of three chambers, and of part of a fourth. 1*a*, anterior end of the same specimen. Cant Hill, St. Minver, Cornwall. Drawn of two-thirds of the natural size. (The reduction of the figure causes the chambers to appear shallower than they really are.)

COPHINOCERAS sp. (Pl. V, Figs. 8*a*, 8*b*.)

The fossil which is here referred to this genus consists of a natural internal cast of a (probably the greater) part of the body-chamber and of the six preceding chambers of a slightly curved shell. It measures on the outer or convex curve about 140 mm., of which the body-chamber occupies about 82 mm. Only one side and a small portion of the other are exposed. The specimen is much flattened, its greatest thickness being only about 28 mm. The greatest width of the fossil is at about the middle of the portion of its septate part, and is about 78 mm., but the boundary of the concave surface of the specimen is not exposed. Of the chambers that are preserved the oldest is the deepest, being at the middle of the lateral area 12·5 mm. deep; in a similar position the two next are each about 10 mm., the next about 8 mm., the two last being each about 6 mm. deep. Near the anterior end of the specimen there is a very broad, ill-defined, shallow constriction, so that the anterior boundary of the fossil, at least the right-hand side of it, probably represents the border of the aperture. The latter does not appear to have been constricted as in the genus *Phragmoceras*, but widely open. The fossil appears to bear slight traces of the ornaments of the test. These are most conspicuous on the body-chamber, and consist of several faint parallel longitudinal ridges from 5 to 12 mm. on the outer, convex, or ventral surface; they extend on to the septate part of the shell, where, however, most of them are much less distinct owing to the roughness of the surface of the specimen, but the innermost ridge, which is at about 30 mm. from the outer boundary of the specimen, is very pronounced and somewhat irregular, as though the test here might have been roughly nodose. On the body-chamber these ridges are connected by transverse, fairly closely-set, but slightly irregular lines crossing the interspaces between the ridges in curves which are forwardly-concave. There are also some rather coarser and more irregular wavy lines near the base of the inner or dorsal portion of the body-chamber, but these may not be traces of any surface ornaments. On the inner or dorsal side of the body-chamber a strongly incised line starts from the last septum at about 12 mm. from the inner edge of the fossil; passing forwards and curving over towards the dorsal side, it reaches the boundary of the fossil at a point about 12·5 mm. in advance of the last septum. Judging from observations in other fossils the writer believes this to indicate the boundary of one of the shell-muscles, this being, in fact, the impression of one of the muscle-scars as it was preserved on the inside of the test, the latter having subsequently disappeared. When received the dorsal portion of the specimen was entirely obscured by matrix, and the fossil looked very much like a portion of a *Phragmoceras*, but the removal of the matrix from the dorsal surface revealed the incised line just referred to, and this suggests to the writer that the fossil is referable to a widely-apertured shell rather than to a form with a contracted aperture such as *Phragmoceras*.

In general appearance the fossil presents some resemblance to the specimen figured by D'Archiac & De Verneuil as *Phragmoceratites subventricosus*[1] from the Middle Devonian of the Eifel, but that species seems to lack the characteristic sculpture of the present specimen.

The fossil appears to be referable to Hyatt's genus *Cophinoceras*,[2] a genus confined to the Middle Devonian, and including both cyrtoceracones or slightly curved forms and gyroceracones or loosely coiled forms. The genotype is *Cyrtoceratites ornatus*, D'Archiac & De Verneuil (Trans. Geol. Soc., ser. II, vol. vi, pt. 2, 1842, p. 349, pl. xxvii, fig. 5), originally described from the

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[1] Trans. Geol. Soc. London, ser. II, vol. vi, pt. 2 (1842), p. 351, pl. xxx, figs. 1, 1*a*. Referred to *Cyrtoceras* (*Ooceras*) *flexuosum*, Schlotheim, sp., by A. H. Foord: Cat. Foss. Ceph. Brit. Mus., pt. i (1888), p. 316.

[2] Proc. Boston Soc. Nat. Hist., vol. xxii (1883), p. 285. See also E. Holzapfel: Abhandl. d. k. Preuss. geolog. Landesanst., Neue Folge, Heft 16 (1895), pp. 123 et seq. Hyatt originally spelt the name *Kophinoceras*, a spelling adopted by Holzapfel; but in Eastman's translation of Zittel's Textbook of Palæontology (1900) Hyatt spells the name *Cophinoceras* (p. 522).

Middle Devonian of the Eifel, but occurring also in the Devonian of Mudstone Bay, South Devon,[1] and to this species the present specimen appears to be allied. Other examples of this genus were figured by Phillips in his work on the Palæozoic fossils of Cornwall, Devon, and West Somerset, and by Whidborne in his Monograph on the Devonian Fauna of the South of England, but the fossil under consideration cannot be definitely referred to any of these, nor indeed to any of the forms described by Holzapfel in his work entitled "Das obere Mitteldevon (Schichten mit *Stringocephalus Burtini* und *Maeneceras terebratum*) im Rheinischen Gebirge."[2] The specimen appears to have been originally somewhat laterally compressed, but it has doubtless suffered considerable additional compression during fossilization. We have not ventured to name this fossil, the affinities of which, however, indicate that it is of Middle Devonian age.

PHRAGMOCERAS (?) sp. (Pl. V, Fig. 7.)

The specimen doubtfully referred to this genus is the small natural internal cast figured in Pl. V, Fig. 7. It is the posterior portion of the septate part of a rapidly expanding shell. It is 15 mm. long, its anterior and posterior diameters being 12 and 6·5 mm. respectively, five[3] chambers being obscurely visible. It is slightly curved, and seems therefore to have been the posterior portion of a *Phragmoceras* rather than of a *Gomphoceras* or *Poterioceras*, but it is too imperfect for accurate determination.

AGONIATITES sp. (Text-figures 2, 2*a*.)

The genus *Agoniatites* is represented by a laterally compressed and very much distorted example (see accompanying figures). The specimen consists of the natural internal cast of the greater part of the body-chamber, and of the two preceding chambers, but is so much crushed that its original dimensions cannot be ascertained. It was evidently a rather rapidly expanding shell. The greatest height at the anterior part of the body-chamber is 42 mm. At the base of the body-chamber (see Fig. 2*a*) the height of the whorl from the margin of the umbilicus to the small median lobe of the suture-line is 27 mm., the greatest width of this part of the shell being 16·5 mm. The periphery appears not to have been acute, but a little flattened, there being indications of such a flattening near the base of the body-chamber, the flattened portion being apparently about 2·5 mm. wide. The curve on the inner edge of the body-chamber (see Fig. 2) shows that the fossil was not very widely umbilicated. Although crushed and considerably distorted, the form of the septal surface shows clearly that the specimen is referable to the genus *Agoniatites*.[1] No signs of sculpture are observable on the side of the body-chamber that is figured, but on the opposite side on the outer portion of the lateral area there are faint regularly-spaced striæ, which are coincident in direction with the septa on the side, but are strongly projected forwards nearer the periphery. This genus is highly characteristic of, if not strictly confined to, the Middle Devonian.

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[1] Described and figured as *Cyrtoceras* (?) *bdellaites* by J. Phillips, Pal. Foss. Cornwall, Devon, and West Somerset, 1841, p. 117, pl. xlvii, figs. 223*a*, *b*, and referred to D'Archiac & De Verneuil's species by A. H. Foord, Cat. Foss. Ceph. Brit. Mus., pt. ii (1891), p. 58.

[2] Abhandl. d. k. Preuss. geolog. Landesanst., Neue Folge, Heft 16 (1895).

[3] Six chambers are indicated in the figure.

Phillips[2] figured and described from South Devon examples of this genus under the names *Goniatites inconstans* (p. 123, pl. li, fig. 238) and *Goniatites transitorius* (p. 140, pl. lx, fig. 227*), whilst Whidborne[3] described and figured in addition to these two other forms *Goniatites obliquus* (p. 56, pl. v, figs. 1–3) and *Goniatites fulguralis* (p. 59, pl. v, figs. 4, 4*a*), which are also referable to this genus,[4] but the present specimen does not appear to be referable to any of these forms. It seems to be comparable rather with such forms as Barrande's *Goniatites bohemicus*[5] and *G. tabuloides*,[6] being, however, more inflated than the latter and possibly not so coarsely ornamented as the former. Both of Barrande's forms come from his Étage G, that is, from the Eifelian or lower portion of the Middle Devonian. Whilst, therefore, the

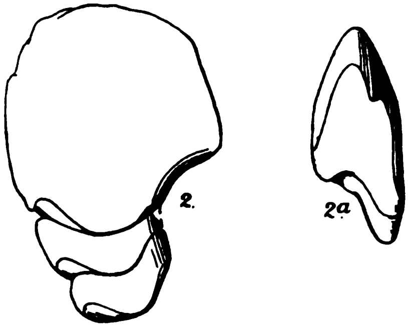

FIG. 2.—*Agoniatites* sp., lateral aspect of internal cast of body-chamber and of two preceding chambers. 2*a*, posterior view of base of body-chamber of the same specimen, showing form of septal surface, the small median lobe being crushed a little to the right side of the specimen. Cant Hill, St. Minver, N. Cornwall. Drawn of two-thirds of the natural size.

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[1] F. B. Meek: U.S. Geol. Explor. 40th Parallel, vol. iv (1877), pt. 1, p. 99.

[2] J. Phillips: "Figures and Descriptions of the Palæozoic Fossils of Cornwall, Devon, and West Somerset" (Mem. Geol. Surv.), 1841.

[3] "Monograph of the Devonian Fauna of the South of England" (Pal. Soc.), pt. ii (1890).

[4] Holzapfel (Abhandl. d. k. Preuss. geol. Landesanst., Neue Folge, Heft 16, 1895, p. 55 et seqq.) unites all these forms into one species—with several varieties—for which he retains Phillips's name *inconstans*, a species which he states to be confined to the Upper Middle Devonian.

[5] J. Barrande: Syst. Sil. de la Bohême, vol. ii, pt. 1 (1867), p. 29, pl. i, figs. 1–13; pl. ii, figs. 1, 2; pl. iii, figs. 15, 16; pl. ccxlii, fig. 1; pl. ccxliv, figs. 3, 4.

[6] Ibid., p. 41, pl. iv, figs. 1–12.

present specimen cannot be specifically determined its affinities seem to indicate that it came from rocks of Lower Middle Devonian age.

Notwithstanding the fragmentary character of the specimens described above, their affinities seem to show that they are all certainly of Devonian and most probably of Eifelian or Lower Middle Devonian age.

In addition to the specimens described above, Mr. Howard Fox has submitted to me for examination some very imperfect fossils from other localities in North Cornwall.

Of the two specimens which are marked "E. of Dinham Creek," one seems to be referable to the fairly common species in the Wissenbach Slates that was described as *Orthoceras longicameratum* by Foord[1] (= *Orthoceras commutatum*, C. G. Giebel[2]). The other, nearly 70 mm. long, is a rather rapidly tapering *Orthoceras*, intermediate in this respect between Roemer's *Orthoceras rapæforme*[3] and his *O. subconicum*,[4] but having shallower chambers than either of these species. Both Roemer's species occur in the Wissenbach Slates.

Among some specimens labelled "Trewornan" are probably *Orthoceras nassoviense*, Foord (= *O. commutatum*, C. G. Giebel), *O. gracile*, Blumenbach,[5] and a fragment of a *Bactrites*. These species of *Orthoceras* are rather common in the Wissenbach Slates, from which two or three species of *Bactrites* have also been recorded.

There are two rock fragments labelled "Gravel Caverns." Of these one contains an obliquely-septated fragment of possibly a *Bactrites*, or more probably an *Orthoceras*, a little more than 10 mm. long; the other a small water-worn Goniatite 2·5 mm. in diameter, with very indistinct suture-lines, belonging to the genus *Tornoceras*.

EXPLANATION OF PLATE V, FIGS. 6–8.

FIG. 6.—*Orthoceras* cf. *hercynicum*, E. Kayser. *a*, entire specimen reduced to two-thirds of the natural size; *b*, anterior aspect of last septal surface, showing the position of the siphuncle, drawn of the natural size. E. of Cant Cove.

,, 7.—*Phragmoceras* (?) sp. Nat. size. Cant Hill, St. Minver, Cornwall.

,, 8.—*Cophinoceras* sp. *a*, lateral aspect of entire specimen, reduced to two-thirds of the natural size; *b*, a portion of the markings on the body-chamber enlarged. Cant Hill, St. Minver, Cornwall.

(For Figs. 1–5 of this Plate, see Dr. H. Woodward's "Notes on Trilobites from Cornwall," pp 151–154.)

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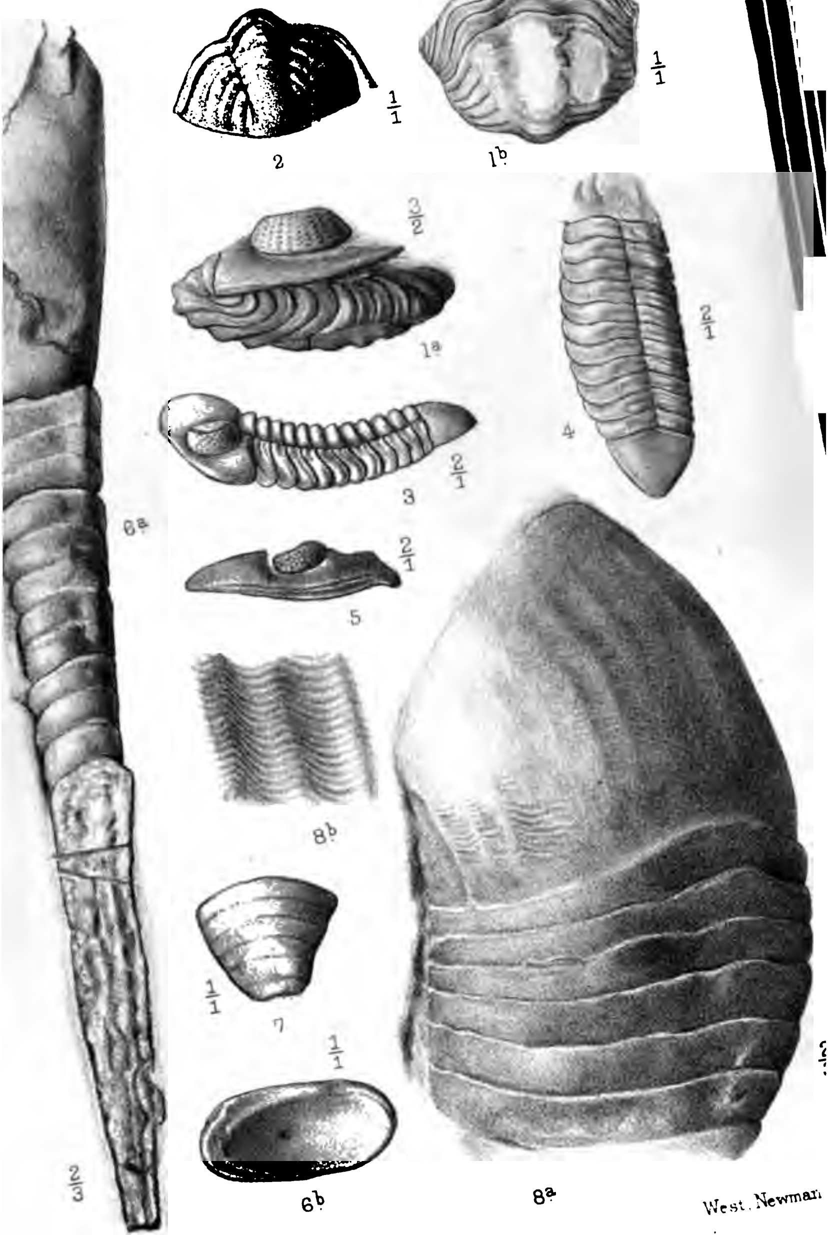
[1] See *antea*, p. 155, footnote.

[2] C. G. Giebel: Fauna der Vorwelt, Bd. iii (1852), p. 233.

[3] F. A. Roemer: Palæontographica, Bd. iii, Lief. 1 (1850), p. 16, pl. iii, fig. 18.

[4] F. A. Roemer: ibid., p. 17, pl. iii, fig. 20.

[5] Blumenbach: Specimen Archæologiæ Telluris, 1803, p. 21, pl. ii, fig. 6.



West, Newman.

G. M. Woodward del et lith.

Devonian Cephalopods and Trilobites from Cornwall.

IV.—*SYMPTERURA MINVERI*, n. g. et sp.: A DEVONIAN OPHIURID FROM CORNWALL.

By F. A. BATHER, M.A., D.Sc., British Museum (Natural History).

(PLATE VI.)

DESCRIPTION OF THE HOLOTYPE.

THE specimen (Fig. 6), kindly entrusted to me for description by Mr. Howard Fox, consists of the oral skeleton surrounded by portions of the disc and of portions of the five rays, all seen from what is believed to be the ventral or actinal surface, and lying on a fragment of the dark slate of the locality, Epphaven. The skeletal parts being preserved in pyrites, it has proved possible to develop the specimen slightly by washing with weak hydrofluoric acid and then brushing with a soft brush. The specimen is, however, so minute and delicate that this process could not be carried very far.

The rays vary in length and, to some extent, in the details shown by each. It is therefore convenient to number them in a solar direction from i to v, i being the longest and v the next in length. These numbers are not to be taken as implying any certain orientation.

Ray i, from its junction with the mouth-parts to the distal portion preserved, is divisible into nine serially homologous segments, of which the ninth or distal-most is incomplete laterally. There is no evidence as to the complete number of segments that originally composed the ray. Those preserved change slightly in character as they approach and enter the disc, which included one of them certainly and a second possibly; but all show the same elements, except for the lateral spines, which are not borne by the segments within the disc. The lateral spines are borne by the free segments 3–8 in groups of three, each group being at the distal outer angle of each segment. The spines of each group diverge fanwise, but the general outward direction of the middle spine of each triad is slightly distal-wards. It is the clear position of these groups of spines which, more than any other feature, enables one to divide this ray into its nine definite segments. Each segment, however, seems capable of subdivision into a proximal and a distal portion (*b* and *a* in Figs. 1 and 2). There is a median body from which proceed two lateral processes or wings on each side. The distal wing has an approximately straight distal margin, lying about at right angles to the axis of the ray, while its proximal margin is deeply excavate. This excavation is clearer in the more distal segments (Fig. 1, *p*), and its boundary there attains a full semicircle. The proximal wing of each segment forms the proximal boundary of this excavation, and, in the more distal segments, its distal margin is slightly excavate. In the proximal segments (Fig. 2) this wing appears more like a flattened rod, slightly depressed on its proximal margin, while the distal wing is also like a flattened rod somewhat scooped out on its ventral surface.

The relations of the wings are perhaps most clearly shown in the eighth segment; here the outer corners of the distal wings seem to overlie processes from the median body (*c* in Fig. 1). The transverse separation of the median body of one segment from that of the next is not very clear. In the distal part of the ray there are indications of a separation not only between the segments, but between the two halves of each segment. The median bodies are slightly grooved on the ventral surface, so that a continuous open groove runs the whole length of the preserved portion of the ray, and passes into the radial angles of the oral skeleton.

Ray v is in a different state of preservation, having apparently been somewhat twisted over on to the side that lies on the right in the figure, so that the ventral groove, which in its proximal region is median, is seen on the right in the distal region. In the preserved portion of the ray the existence of four distinct segments is pretty clearly indicated by transverse ridges and indentations, also by two spines, one at the distal end of the third segment, the other at the end of the fourth, both on the left-hand in the figure. Apparently there are here preserved only the median bodies, a fact which might suggest that they were distinct elements from the side-wings. There are, however, traces of the wings on the left of the second and third segments. In none of these segments is there a clear indication of a subsidiary transverse division.

The other rays are too incomplete to throw any light on the structure of the segments, but in their proximal segments the side-wings are to be distinguished, especially in ray iv.

The oral skeleton (Fig. 3) is divisible into five radial portions, each of which is bilaterally symmetrical about the radius, and at first sight appears to consist of two curved bars or syngnaths enclosing a lanceolate space, of which the apex is distal, while the proximal ends of the bars approach closely those of the adjacent bars on each side. More minute examination shows that each of the supposed curved bars consists of three elements, to which may be applied the terminology adopted by Dr. J. W. Gregory, the distal element being a 'mouth-frame,' the proximal one a 'tooth,' and the intermediate one a 'jaw.' Of these three elements the jaws are the longest, and broaden at their distal ends; the distinction between them and the mouth-frames is marked either by a sharp bend or an actual gap. The mouth-frame is about two-thirds the length of the jaw; each pair is joined distally to the median body of the proximal ray-segment. The teeth also are distinguished from the jaw by a sharp bend at the point of union, while they lie a little above the jaw as one views the specimen from the ventral surface. There is no sign of a 'jaw-plate' or 'torus angularis'; there may have been a small one, or the structures here called 'teeth' may represent primitive unfused elements of the torus, such as have been observed in the development of recent Ophiurids. Fewkes states that in *Amphiura* the teeth grow out from the torus and have no independent *centres* of calcification.

The disc is best preserved in the interradius v–i. It certainly extended up the rays to the distal end of the first segment (*d* in Fig. 2), and perhaps a little further, but whether its outline was straight or concave interradially cannot be decided. It was clothed with minute spines radiating from the centre.

The following are some measurements of the specimen in millimetres:—

Greatest length of the portion preserved	11·5
Diameter of disc	*circà* 6·5
From centre to distal end of mouth-skeleton	*circà* 2·0
Width of ray	1·5
Length of lateral spines, at least	1·8
Average length of a segment	·76

INTERPRETATION OF THE HOLOTYPE.

Owing to the difficulties of interpretation, the foregoing description of the rays has been drawn up in as objective a fashion as possible. Some interpretation, however, is a necessary preliminary to any discussion of the relationships of the fossil.

The median body of each segment is undoubtedly the equivalent of the normal Ophiurid vertebra. On the accepted theory that this vertebra was evolved by the fusion of a pair of ossicles originally alternating, then opposite, and finally joined along the middle or radial line, the present specimen may be described as in a stage of development later than the fusion, but possibly retaining in the median groove a trace of the primitive distinctness of the ossicles. Those ossicles are usually described as ambulacral, and that term may be accepted so far as it denotes homology with the ossicles so named in an Asterid. (See Note at end.)

It was the existence of the median groove that first suggested the determination of the exposed surface of the fossil as ventral. But since such a groove may occur also on the dorsal surface of a vertebra, that evidence is inconclusive. The determination is confirmed, however, by the conspicuousness of the subcircular excavations, or podial pores, in the side-processes, and by the apparent continuation of this groove over the radial angles of the mouth-frames.

As a rule among Ophiurids in this stage of evolution, each vertebra has on each side a single side-process on which abuts an outer ossicle, the so-called adambulacral, and these adambulacrals, which bear the lateral spines, alternate with the ambulacral ossicles or vertebræ. It is a little difficult to interpret the appearances of the present specimen in harmony with such an arrangement. On the assumption that each segment should contain one ambulacral pair (here fused) and one adambulacral pair bearing spines, ray i has been assigned nine segments. But each such segment is seen to have two processes on each side, and the distal one of these bears the spines. For this reason, and because of the appearances in segment 8, it may be supposed that the outer spiniferous portion of the distal process (*c* in Fig. 1) is an adambulacral element. What, then, is the proximal side-process? To this question two possible answers present themselves.

The appearance of a transverse division in the vertebra, between the proximal and distal processes, suggests that each segment really consists of two ambulacral pairs, of which only the distal one is associated with adambulacrals, the proximal pair of adambulacrals being suppressed. Each of these supposed ambulacral pairs possesses a single pair of lateral processes, but those of the distal pair are partly overlaid by the adambulacral elements. In the distal region of the ray the proximal and distal halves of the vertebra are distinguishable; but nearer the disc and within it they have come closer together, the transverse division has disappeared, and the side-processes are reduced to structures which appear as bars, but are probably flattened laminæ. Thus the vertebræ seen in ray v are, on this explanation, of compound origin.

The preceding interpretation may be compared with Dr. Gregory's interpretation of the structure in the Lower Devonian Ophiurid, *Bundenbachia*[1] (see our Fig. 5). Here "the body of the [ambulacral] ossicle is apparently divided into two pieces by a transverse depression. The adambulacral plates are small and narrow, and support a triangular spine-bearing plate." If, however, as seems legitimate, this last plate be regarded as itself an adambulacral element, then each segment will consist of two ambulacral pairs, and two adambulacral pairs of which one only is spiniferous. The fact that in *Bundenbachia* the ambulacrals still alternate does not affect the composition of the segment. *Bundenbachia* is not to be regarded as a direct ancestor of the contemporary Epphaven fossil, but it suggests the possibility that, during the race-history of the Ophiurids, there may have arisen forms with a tendency to suppression of alternate adambulacrals and to fusion of adjoining ambulacrals.

In *Bundenbachia* there appear to be preserved both adambulacral and ambulacral elements of the subsequently suppressed or coalesced segment. The Silurian *Protaster Sedgwicki* appears to retain the ambulacral elements less reduced than in *Bundenbachia*, while it has lost the adambulacral elements. In the proximal arm-segments, however, as figured by Dr. Gregory (op. cit., fig. 1*c*), the existing adambulacrals are forked, a peculiarity suggestive of their compound origin.

Now comparison of the vertebræ of recent Ophiurids with the arm-segments, especially the proximal ones, of our fossil leaves no room for doubt that the depression marked *p* is for the reception of a podium, while that marked *q* is for the insertion of the ventral inter-vertebral muscles. A single arm-segment of a recent Ophiurid. such as *Ophiarachna* or *Amphiura*, is therefore homologous with any one of the whole segments here numbered 1–8. If one of these is really composed of a distal and a proximal half (lettered *a* and *b* respectively in Figs. 1 and 2) the same statement would apply to the recent Ophiurid, and some trace of this origin might be seen in the development. The observations of Professor Ludwig[2] and

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[1] Proc. Zool. Soc. London, 1896, p. 1033; 1897.

[2] Zeitschr. wiss. Zool., vol. xxxvi, p. 181; 1881.

Mr. J. W. Fewkes[1] on *Amphiura squamata* have shown that the two lateral halves of each vertebra unite first at the proximal and distal ends, leaving a space between. This is suggestive of an origin from proximal and distal elements. On the other hand, each lateral half springs from a single centre of calcification, from which it stretches out in a distal direction, so that the incipient ambulacral element is thicker at its proximal end. This last-mentioned feature is paralleled by the boot-shaped proximal portions of the ambulacral ossicles in the Protasteridæ. At a slightly later stage the ambulacral of *Amphiura* broadens at the distal end, which thus comes to resemble the distal portion of the Protasterid ambulacral. If this distal portion in *Amphiura* were, as indicated by Professor Ludwig's observations, merely an extension of the proximal portion, then it might be inferred that the whole structure, both here and in the various Palæozoic forms alluded to, represented a single ambulacral pair and not two successive pairs. In such case one would accept Dr. Gregory's suggested explanation (op. cit., p. 1082) "that the smaller pieces are only triangular, distal portions of the ambulacral ossicles, apparently separated from the proximal portion[s] by a groove." Dr. Gregory further suggests that these grooves or depressions "were for the lodgment of the ventral muscles which moved the arms." A far more probable explanation surely is that they were for the reception of the branches from the radial water-vessel to the podia. This explanation, however, consonant as it is with the facts of development in *Amphiura*, reminds one of another difficulty. Professor Ludwig (op. cit., p. 185) has pointed out that, whereas the so-called ambulacrals of Asterids lie at right angles to the perradius and between the successive branches and podia, those of Ophiurids lie parallel to the perradius and across the branches to the podia. Now if, as we have every reason to believe, the Ophiurids were derived from Asterids, it is hard to see why this change should have taken place. That is the difficulty, but it is a difficulty that disappears if we suppose that the vertebra is really compounded of two successive ambulacral pairs in the manner outlined above. The remaining objection to this latter hypothesis is that, as Dr. Gregory has pointed out, it postulates the suppression of alternate podia. Nevertheless, similar fusion and concomitant suppression are not so unknown among Echinoderms as to render this objection a fatal one.

The suggestion that the vertebræ of Ophiurids are composed of two successive ambulacral pairs certainly cannot be proved with the evidence at our disposal. But it is doubtful whether it can be disproved, and I therefore make it to promote a search for further evidence *pro* or *con*.

Two other features in the present specimen need discussion, and may perhaps throw light on the problem just posed. The first of these is the fact that the broadest and stoutest portion of each arm-segment appears to be the distal half (marked *a* in Fig. 1), whereas in the developing *Amphiura* and in the adult Protasteridæ

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[1] Bull. Mus. *Comp. Zool. Harvard*, vol. xiii, No. 4; 1887.

the reverse is the case. This character is also found in *Furcaster palæozoicus* as figured by Mr. Stürtz, in *Ptilonaster princeps* of J. Hall, and in *Lapworthura Miltoni* as interpreted by Dr. Gregory (see our Fig. 4). In the Epphaven fossil the feature is to some extent accounted for by the supposed fusion of a spiniferous adambulacral element with the distal wing of the ambulacral; but in *Lapworthura* and *Furcaster* this wing, while unconnected with the adambulacral, is still more preponderant. In some other early Palæozoic genera, e.g. *Eugaster*, J. Hall, and *Eophiura*, Jaekel, the wing is neither distal nor proximal, but arises half-way up the ambulacral, so that one cannot say to which of two successive segments the podium belongs: in fact, the structure is in this respect absolutely that of an Asterid.[1] These differences call for some explanation. Starting from the indifferent Ordovician type of *Eophiura*, we may suppose that in one series of genera (e.g. Protasteridæ) the wing moved towards the mouth, while in another series (e.g. Lapworthuridæ) it moved away from the mouth. In both series the podium ultimately became enclosed within the substance of (apparently) a single ossicle; but, if this took place by a subsequent lateral outgrowth of stereom, then in the former case the vertebra must have enclosed a podium distal to itself, and in the latter case a podium proximal to itself. Thus the relations of the vertebræ to the podia would be fundamentally different in the two lines of descent. On the other hand, alternate podia may, as suggested on a previous page, have been enclosed by the union of successive pairs of vertebræ, and this type of structure may be the one seen in process of development in the arm-segments of our fossil, and the one that persisted to the present day.

The second feature worthy of attention is the considerable space that seems to intervene between the distal wing of one segment and the proximal wing of the next. This is conspicuous in the distal region of ray i, where, further, the depression (*q* in Fig. 1) markedly resembles the podial depression (*p* in Fig. 1), and differs from it mainly in being rather nearer the axis of the arm. The theory that the Ophiurids are descended from Asterids does not explain the evolution of such an interspace, and the general tendency to shortening and approximation of the vertebræ, shown in the history of the Ophiurids, leads one to enquire why there should ever have been introduced a stage in which, as in the Devonian *Ophiurina*, the recent deep-sea *Ophiohelus*, and the young *Amphiura*, the vertebræ have so far departed from the primitive type as to become axially elongate. This stage has been regarded as primitive by Lyman, Ludwig, and other zoologists, but in theory and fact it is 'primitive' only so far as the later forms are concerned, while with reference to the complete series it is 'intercalated.'

Recurring to the hypothesis that the vertebræ are compounded of successive pairs of ambulacrals, we find in it an explanation not

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[1] See Dr. O. Jaekel's interesting account of genera from the Lower Palæozoic rocks of Bohemia, intermediate between Asterids and Ophiurids: Zeitschr. Deutsch. geol. Ges., lv, Protok. pp. 106–113; 1904. References to the older literature will be found in Dr. Gregory's oft-quoted paper.

merely of this curious elongation of the arm-segments in general, but of the interspaces between them in this genus (lettered *q*). An objection to the hypothesis was the necessity for assuming the suppression of alternate podia. Here, it may be, is evidence of a stage in which those podia were not yet suppressed, though perhaps somewhat atrophied. If both depressions (*p* and *q*) were for the reception of podia, then their alternate approximation to and removal from the perradius may be compared with the similar phenomenon in Asterids.

Whether the features just discussed be or be not accepted as evidence in favour of the compound origin of the Ophiurid vertebra, they demand some explanation; and it may be added that the same hypothesis will perhaps furnish an equally needed explanation for the hitherto unexplained differences that obtain between Palæozoic genera of Ophiurids in the relations of the adambulacrals to the ambulacrals.

The origin of the Ophiurid mouth-skeleton also may be illuminated by the preceding hypothesis, which is in full harmony with the opinion that many more arm-segments enter into the composition of that structure than is the case in Asterids, an opinion based on embryological research by Dr. O. zur Strassen,[1] and on palæontological investigation by Dr. O. Jaekel in the paper quoted above. In this region of the ray, at any rate, adambulacrals and podia must have been suppressed in all Ophiurids. We may here note the apparent absence from our specimen of the adambulacral elements known as side mouth-shields, as well as of the peristomial plates. The latter are wanting in most early Ophiurids, a fact confirmatory of Dr. zur Strassen's conclusion that they are not ambulacral elements, but "secondary calcifications confined to the interradial region."

SYSTEMATIC POSITION.

In considering the systematic position of this fossil we have two systems to choose from: one, that proposed by Dr. Gregory in the paper above quoted, and adopted by him in "A Treatise on Zoology" (ed. Lankester, London, 1900); the other, the latest classification by Mr. B. Stürtz (Verh. nat. Ver. preuss. Rheinlande, lvi, p. 198, 1900). The two classifications have much in common, and, without discussing their respective merits, it will be convenient to start with Dr. Gregory's as more accessible to English readers.

The union of the ambulacrals into vertebræ removes the fossil from the Order Lysophiuræ and from the Streptophiuran Family Ophiurinidæ, while the absence of a covering integument or scutes prevents it being placed in any of the other Orders or in any Family of Streptophiuræ other than Lapworthuridæ or Eoluididæ. Of these two Families the former has no ventral arm-plates, and the latter, while having ventral ones, has no dorsal arm-plates, except in *Aganaster*. If the exposed surface of this fossil be rightly regarded as ventral, the specimen must belong to the former Family. The genera herein contained are *Lapworthura*, Greg., *Furcaster*, Stürtz, and *Palastropecten*, Stürtz (syn. *Palaeospondylus*, Stürtz). The last of these differs from the Epphaven fossil in almost every respect, but the two others present a slight general resemblance in arm-structure. In each, for instance, the vertebral body has distal wings, and in *Lapworthura* these wings surround large subcircular pores; but in both the adambulacrals have a different position, while there is no proximal wing, although the diagram of *Lapworthura* given by Dr. Gregory and here repeated (Pl. VI, Fig. 4) shows a minute incipient process. In the known species of these genera also the disc extends further down the rays, which are relatively wider, while the proportions of the various elements of the mouth-skeleton are different.

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[1] Zool. Anzeiger, xxiv, p. 609; Nov. 1901.

The Family Eoluididæ includes *Eoluidia*, Stürtz (syn. *Eophiurites*, Stürtz), *Eospondylus*, Greg., *Miospondylus*, Greg., *Aganaster*, Miller & Gurley (syn. *Ophiopege*, G. Böhm), and perhaps *Cholaster*, Worthen & Miller. The last two have both ventral and dorsal arm-scutes, while as for the others they differ in much the same respects as do *Furcaster* and *Lapworthura*, only to a greater extent and with no superficial resemblance.

It seems therefore safest to place this fossil in the Lapworthuridæ, with the diagnosis of which it agrees so far as the structure is known. If the subdivision of Gregory's Family into Lapworthuridæ, Furcasteridæ, and Palæospondylidæ (i.e. Palastropectinidæ), as proposed by Stürtz, should be accepted, our fossil would still be most appropriately placed in Lapworthuridæ. It is, however, quite impossible to refer it to *Lapworthura* itself, and a new genus must be established for its reception. From a geological point of view it would have been more interesting could one have referred it to some known species, or at least genus, found in the Devonian of Germany. But repeated comparison with the rich material in the British Museum has proved this course inadmissible, whatever errors there may be in the details of the present interpretation.

SYMPTERURA,[1] nov. gen.

A Lapworthurid with spinulose disc extending to second arm-segment, with oral skeleton of teeth, long jaws, and short mouth-frames (torus not seen), with free arm-segments containing a vertebral ossicle, possibly compound, grooved ventrally and provided on each side with two wings, to the distal of which is attached an adambulacral spiniferous element.

Genotype. *Sympterura Minveri*, n.sp.

This being the only known species, a diagnosis is impossible, but attention may be directed to the relative narrowness of the rays, the extension of the disc, and the length and number of the spines.

Holotype, a unique specimen collected by Miss Barbara Legg in the blue slate of Epphaven, which is a cove between Lundy Beach and Trevan Point in Portquin Bay, in the parish of St. Minver, near Padstow, North Cornwall. When Mr. Howard Fox was so good as to send me the specimen for examination, I acknowledged

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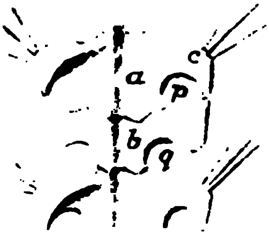
[1] σὺν and πτερὸν, 'paired wings,' and οὐρά, 'tail,' as in *Ophiura*, *Lapworthura*, etc.



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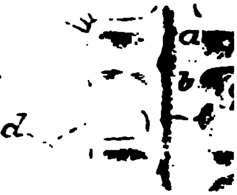

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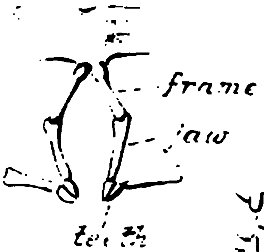

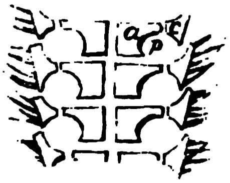

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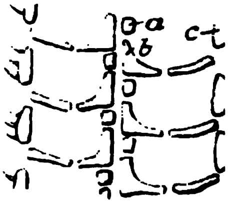

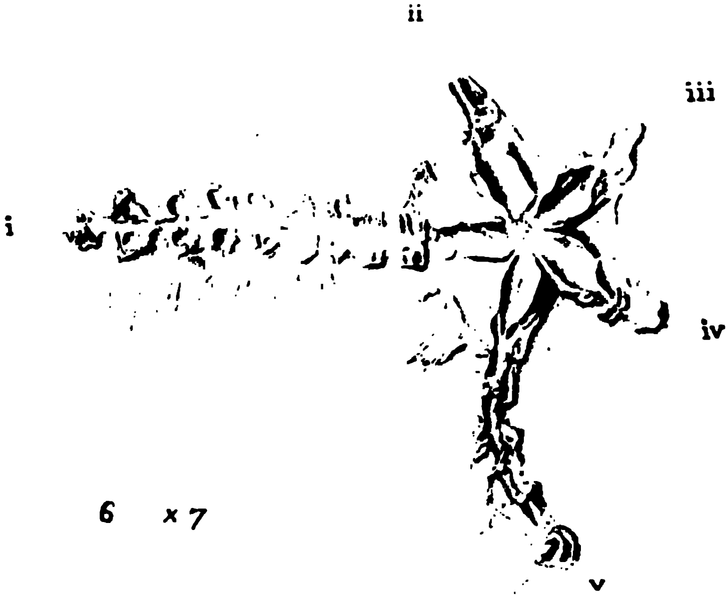

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Sympterura Minveri

its receipt in a rather informal letter, extracts from which have since been published by him (Trans. R. Geol. Soc. Cornwall, xii, p. 752, Sept. 1904). One sentence ran: "So far as I can judge without more prolonged study [the fossil] is either *Ophiurina* or a close ally." The structure had not then been developed by etching and brushing. It is now quite clear that the specimen has nothing to do with *Ophiurina*, which is in the Lysophiuran stage, with long rod-like unfused ambulacrals. Mr. Fox has since kindly presented the specimen to the British Museum, where it is registered E 5,036.

Horizon.—The rock is certainly Devonian, but on its precise age the present specimen, being of a new generic type, can throw little light. The stage of evolution at which *Sympterura* stands, namely, primitive Streptophiuran, is fully consistent with a Lower Devonian age.

NOTE.—In this paper I have used the term 'ambulacrals' for the elements of which the Ophiurid vertebra is composed, and in so doing have followed the general custom. But many writers, from Johannes Müller onwards, have contended that the so-called ambulacrals of Asterids and Ophiurids are not homologous with those plates in Echinoidea for which the term was originally proposed. This contention has much in its favour. At any rate, the so-called ambulacrals of Asterids are homologous with the flooring plates of the subvective groove in Edrioasteroidea, and not with the covering plates, which latter are usually called ambulacrals, as in Pelmatozoa generally.

For practical purposes also, I have used the ordinal names Streptophiuræ and Lysophiuræ, proposed by Mr. F. J. Bell and Dr. J. W. Gregory respectively. But it seems to me that the divisions adopted by my friends and colleagues represent stages of development rather than divergent groupings, and while admitting the great interest and value of the conceptions, I cannot follow Dr. Gregory in ranking them as Orders.

EXPLANATION OF PLATE VI.

FIG. 1.—***Sympterura***, semi-diagrammatic reconstruction of the 8th arm-segment and part of the 7th. *a*, distal portion of the vertebra; *b*, proximal portion; *c*, adambulacral; *p*, podial depression or pore; *q*, interspace, occupied, at least in part, by intervertebral muscles. × 18 diam.

" 2.—***Sympterura***, semi-diagrammatic reconstruction of the 2nd arm-segment and part of the 1st. *a*, *b*, *c*, *p*, *q*, as in Fig. 1; *d*, border of disc. × 18 diam.

" 3.—***Sympterura***, semi-diagrammatic reconstruction of part of the mouth-skeleton. × 10 diam.

" 4.—***Lapworthura***, diagram of the arm-structure, after Gregory, Proc. Zool. Soc. London, 1896, p. 1037. *a*, *c*, *p*, as in Figs. 1 and 2.

" 5.—***Bundenbachia***, diagram of the arm-structure, after Gregory, op. cit., p. 1034. *a*, *c*, *b*, as in Figs. 1 and 2. Dr. Gregory is not responsible for the lettering in Figs. 4 and 5.

" 6.—***Sympterura Minveri***, the unique specimen. The numbering of the rays is for convenience only. In drawing this figure I was helped by preliminary sketches made by Mr. W. Lewis before the specimen was fully cleaned. × 7 diam.

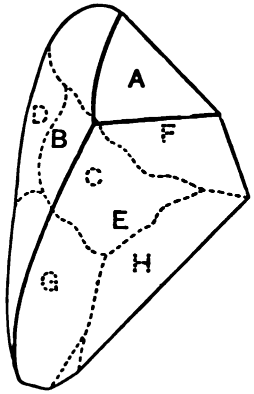
All figures represent views of the ventral surface. The drawings are reproduced by the London Stereoscopic Company, Limited.

V.—A Description of the Big Diamond recently found in the Premier Mine, Transvaal.

By F. H. Hatch, Ph.D., F.G.S., and G. S. Corstorphine, Ph.D., F.G.S.

(PLATES VII AND VIII.)

GREAT interest has been excited, not only in the Transvaal, but throughout the world, by the discovery at the Premier Mine, on Wednesday, the 25th January, 1905, of the largest diamond hitherto known. The stone was found by Mr. Wells, Surface Manager, in the yellow ground about 18 feet from the surface, a brilliant flash of light from a projecting corner having caught his attention. After a preliminary cleaning it weighs 3,024¾ carats. According to Gardner Williams the South African carat is equivalent to 3·174 grains; consequently the diamond weighs 9600·5 grains troy or 1·37 lbs. avoirdupois. Through the courtesy of the Directors of the Company, we have been enabled to make an examination of the stone, with the following result:—Roughly speaking, it measures 4 by 2½ by 2 inches; but its size and shape will be best realized by reference to the photographs reproduced on Plates VII and VIII, which represent the diamond from four different points of view and its actual size. These beautiful photographs were taken by Mr. E. H. V. Melvill for the purposes of this description. The stone is bounded by eight surfaces, four of which are faces of the original crystal, and will be referred to in this description under the letters A, B, C, D, and four are cleavage surfaces, the cleavage being of course parallel to the face of the octahedron. In the following description these cleavage surfaces are referred to under the letters E, F, G, H. They are distinguished from the original octahedral faces by greater regularity and smoothness. The shape and relative position of these various surfaces can be seen in the diagrammatic



Diagrammatic Projection (to half scale).

projection depicted in the Text-figure, which has been drawn in the Mineralogical Laboratory of the Oxford University Museum, by the kind permission of Prof. Miers, F.R.S. The drawing is to half scale.

Description of the Surfaces.

A is an original octahedral face showing typical striations, the bands varying from 0·1 to 0·4 centimetre, and running parallel to the edge A–E.

B is a large surface slightly curved showing partial striations, which, however, are interrupted by the slightly mammillary character of the surface.

C is also a natural surface showing a few striations parallel to the edge C–E.

D. Between B and F, C, G, there is an irregular octahedral face D, showing distinct equilateral triangular indentations which resemble etched figures, except in regard to their comparatively large size, the largest having a side measuring 0·7 centimetre. D is parallel to E.

E, F, G, H, are cleavage planes.

E is the largest of these, and is a very perfect cleavage plane. Parallel to it within the crystal there is a small air layer between two internal cleavages, producing a 'rainbow' or Newton's rings.

F is the second largest of the cleavage planes and shows a small spot within the crystal.

G is an irregularly shaped cleavage plane.

H is another cleavage face showing series of cleavages in the corner bounded by E and G. Two spots are visible, one actually on the surface, the other about 1 cm. within the crystal.

Of the faces given, A and G, H and B, and E and D are parallel. In the case of B and H the parallelism is imperfect owing to the curvature of B.

The purity of the crystal is best seen on looking into face E, and the lustre is well seen on the irregular natural face B, the broken cleavage on H causing a good deal of refraction which affects B to some extent as the facets of a cut gem would. For a large stone the crystal is of remarkable purity, and the colour approximates to that of a blue-white.

The large size of the cleavage planes E and F indicates that a very considerable portion of the crystal is wanting. From the shape of B, D, and G, one can say that the entire crystal was irregular in shape, but A and D being octahedral faces, the presumption is that the complete crystal was a distorted octahedron, probably with dodecahedral faces developed on the edges. The portions missing probably amount to more than half of the original crystal.

The Cullinan diamond, as it has been named, after the Chairman of the Premier Company, is more than three times the weight of the largest diamond previously known—the famous stone found in 1893 at Jagersfontein in the Orange River Colony, which weighed 972 carats.

EXPLANATION OF PLATES.

PLATE VII.

FIG. 1 shows the original face A at the top of the stone. In front is the cleavage plane E, which, however, is not clearly visible owing to the light reflected from the somewhat irregular surfaces at the back of the crystal. On the extreme right is the cleavage plane H.

FIG. 2 shows the cleavage plane F, which, on account of its favourable position relative to the camera, appears as a brilliantly illuminated surface; the irregular original faces C and D also appear in this view.

PLATE VIII.

FIG. 3 shows the triangular indentations on the irregular face D: also portions of A and B.

FIG. 4 shows the crystal resting on the cleavage plane E with the faces B and D exposed to view. The sharp bounding edges are formed as follows: at the bottom by E, on the right by A, and on the left by G.

VI.—THE CLASSIFICATION OF THE PHACOPIDÆ.

BY F. R. COWPER REED, M.A., F.G.S., of the Sedgwick Museum, Cambridge.

THE family of Trilobites termed Phacopidæ has been defined by Beecher[1] as follows:—"Glabella tumid, widest in front. Free cheeks continuous, united anteriorly. Suture extending from in front of the genal angles inward to the eyes, and thence forward around the glabella. Eyes generally large, always with distinct facets, schizochroal. Thorax of eleven segments with grooved pleura. Pygidium usually large and of many segments; limb ribbed; margin entire or dentate."

Nomenclature in use.

While the general limits and characteristics of the family as thus given are universally recognised, much confusion and diversity of opinion still exist as to the generic groups which must be therein included. There is no precise agreement in the usage of many of the common generic names; and many subgenera have been from time to time established without general acceptance. Some palæontologists (e.g. Salter) have been of the opinion that the family only contained one genus, *Phacops*, which might be split up into several subgenera. Barrande, however, recognised the presence of two genera, *Phacops* (in a more restricted sense than Salter) and *Dalmania* or *Dalmanites*; and Hall & Clarke in 1888[2] adopted this view. Beecher in 1900 (op. cit.) mentioned six divisions or groups within the limits of the family, and put them all as of equal generic value.

Other examples of differences in the classification of the family need not here be given; but in order to show the multitude of generic or subgeneric groups which have been established, but of which only a few have been generally adopted, the following list

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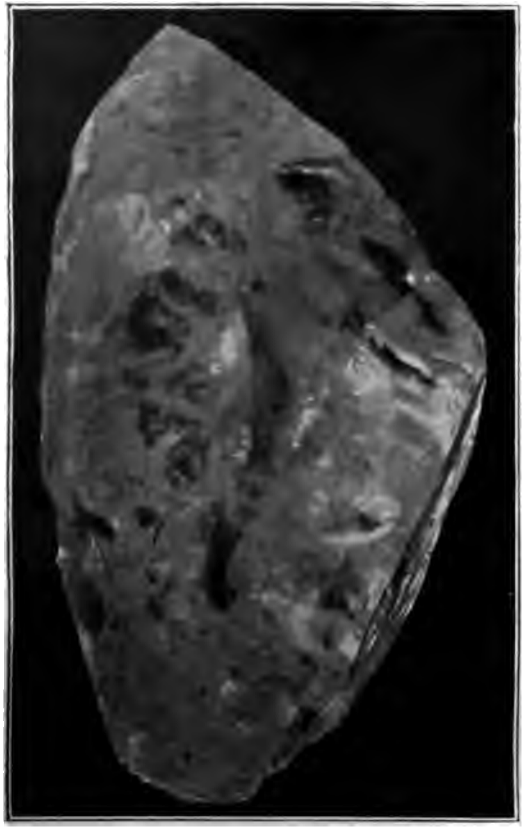
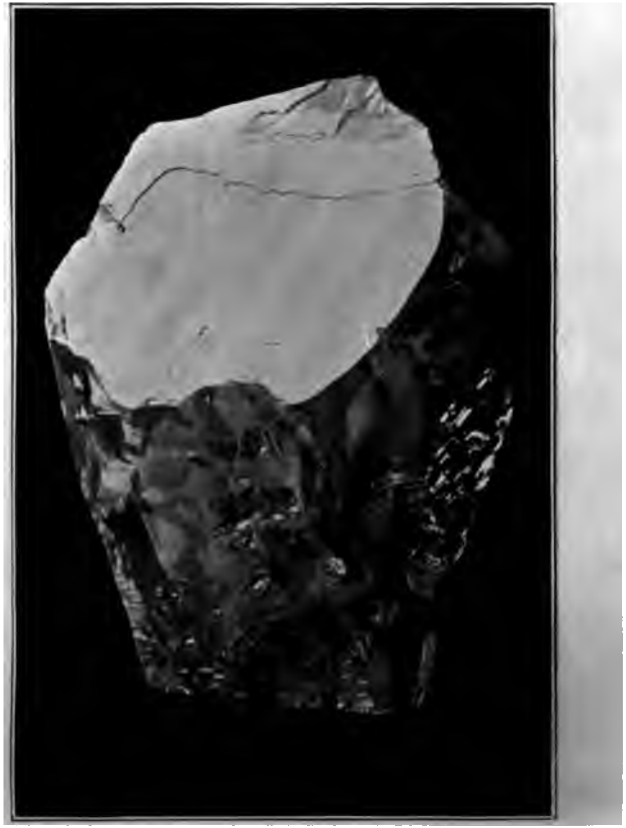
[1] Beecher, Amer. Journ. Sci., vol. iii (1897), p. 202; and in Zittel's "Textbook of Palæontology" (English translation, 1900), p. 636.

[2] *Hall & Clarke:* Palæont. New York, vol. vii, pp. xxvii–xxxii.





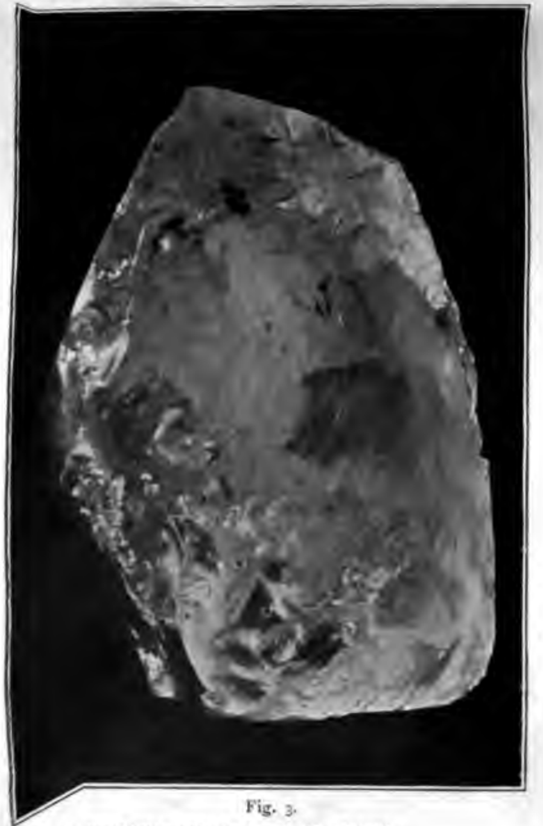


Fig. 3.

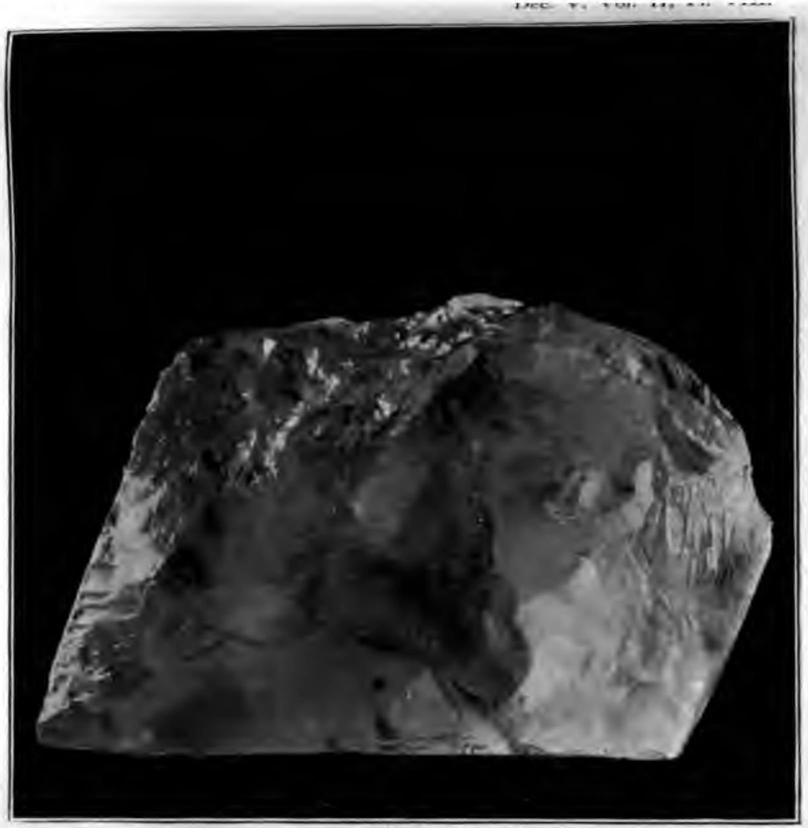


Fig. 4.

From Photographs by E. H. V. Melvill.

may be given, irrespective of questions of synonymy or preoccupation, which will be dealt with subsequently :—

Acaste, Goldfuss, 1843.
Asteropyge, Corda, 1847.
Chasmops, McCoy, 1849.
Coronura, Hall & Clarke, 1888.
Coryecephalus, Hall & Clarke, 1888.
Cryphæus, Green, 1837.
Cryphina, Oehlert, 1889.
Dalmania, Emmrich, 1844.
Dalmanites, Barrande, 1852.
Hausmannia, Hall & Clarke, 1888.
Homalops, Remelé, 1884.
Malladaia, Oehlert, 1896.
Metacanthus, Corda, 1847.
Monorakos, Schmidt, 1886.
Odontocephalus, Conrad, 1840.
Odontochile, Corda, 1847.
Phacops, Emmrich, 1839.
Pleuracanthus, Milne-Edwards, 1840.
Portlockia, McCoy, 1846.
Probolium, Oehlert, 1889.
Pterygometopus, Schmidt, 1881.
Somatrikelon, McMurtrie, 1819.
Synphoria, Clarke, 1894.
Trimerocephalus, McCoy, 1849.

Of the above names, *Pleuracanthus* and *Cryphæus* are both preoccupied, the former both by a genus of Coleoptera (Gray, 1832) and by a genus of fishes (Agassiz, 1837), the latter by a genus of Coleoptera (Klug, 1833). *Cryphæus* was founded on the American species *Cr. Boothi*, Green, of which *Cr. callitelus*, Green, which possesses a median terminal spine to the pygidium as well as the five lateral pairs, was considered merely a variety by Hall.[1] Corda, in dealing with the similar European species *C. arachnoides* (Hoeninghaus) and *C. stellifer*, Burmeister, considered the presence or absence of the terminal spine a feature of generic importance; and accordingly put them in separate genera, which he called *Asteropyge* and *Metacanthus* respectively. Salter[2] was the first to denounce the artificiality and weakness of this division; so that, as *Cryphæus* is not available as a generic or group name, *Asteropyge* must be used as its designation. Kayser[3] has endeavoured to subdivide *Cryphæus* again into Corda's two sections.

Though the type-species of *Dalmania* is *D. caudatus* (Brünn.) and that of *Odontochile O. Hausmanni* (Brong.), (or as Barrande declares *D. Reussi*, Barr.), yet it was early recognised that these species were congeneric. Both *Dalmania* and *Odontochile* were unfortunately preoccupied, the former by a genus of Diptera (Robineau Desvoidy, 1830) and the latter by a genus of Coleoptera (*Odontocheila*, Laporte, 1834), so that Barrande proposed the name *Dalmanites*, which though often used in a very wide sense, yet must hold good as the group-name of which the type-species is *D. caudatus*. Hall & Clarke[4] employed the name *Dalmanites* in such a wide sense that they proposed the name *Hausmannia* for the sub-group containing the type-species; but Oehlert[5] considers it an unnecessary duplicate name.

Acaste must be considered as preoccupied, the name *Acasta* having been given by Leach in 1811 to a genus of Cirripedes. There is no strict synonym for this group, so that the name must be replaced by a new one if the morphological or phylogenetic claims of the group which it marks are sufficient to warrant a distinctive title.

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[1] Hall & Clarke: op. cit., p. 45.

[2] Salter: Mem. Geol. Surv., dec. ii, 1849, art. 1, p. 8.

[3] Kayser: "Die Fauna ält. Dev. Ablag. Harzes," p. 33 (Abhandl. geol. spec. Kart. Preuss., Bd. ii, Heft 4, 1878).

[4] Hall & Clarke: op. cit., p. xxxi.

[5] Oehlert: Bull. Soc. Géol. France, sér. III, vol. xvii (1889), p. 758.

The divisional names, therefore, which remain after this preliminary weeding-out are the following :—

'Acaste.'
Asteropyge.
Chasmops.
Coronura.
Corycephalus.
Cryphina.
Dalmanites.
Homalops.
Malladaia.
Monorakos.
Odontocephalus.
Phacops.
Portlockia.
Probolium.
Pterygometopus.
Somatrikelon.
Synphoria.
Trimerocephalus.

Whether all the above divisions have sufficient morphological or phylogenetic value to be retained in a natural system of classification is the question now to be discussed.

Principles of Classification.

Dismissing from our minds all ideas and prejudices derived from customary usage and past authorities, it is worth while considering in what manner we should group the members and species of the Phacopidæ supposing we were to start completely *de novo.* The principles for a natural arrangement are acknowledged to be found in the modifications of the head-shield, as we have learned especially from Professor Beecher's valuable researches. In the case of the members of a compact family such as the Phacopidæ the changes in the glabella offer the best guide, and these changes are shown by the fusion or reduction or even disappearance of certain lobes. The modifications in the thorax, which always retains the fixed number of eleven segments, are of secondary morphological value and of minor developmental importance; and while there is an immense amount of variation in the characters of the pygidium in shape, number of segments, and ornamentation, yet the evidence of the trilobites as a whole and of individual families (e.g. the Cheiruridæ) indicates that structural changes in this part of the body occur in less regular succession and pursue often an independent or eccentric development, so that for the purposes of a classification which is intended to be based on phylogeny they are of less significance than those in the head-shield.

Starting, then, from the well-established view of the primitive pentamerous composition of the head-shield of trilobites, we may expect to find this pentameric segmentation best exhibited in the earliest and least modified members of the family. The phylogeny may be anticipated to follow the ontogeny which has been traced in more than one species of *Phacops.*

The group termed *Dalmanites* by Barrande, using the name in its widest and most comprehensive sense, most clearly preserves the fivefold division of the head-shield. In the early post-embryonic stages of its species, as well as at maturity, the five segments are well displayed. The retention of this primitive character throughout the whole history of the group must be undoubtedly interpreted as of considerable importance, though even in the larval stages some tachygenetic features appear which stamp the group as belonging to one of the higher and later families of trilobites. There does not seem to be any reason for considering the pentamerism of the later and more specialised forms of *Dalmanites* as signs of retrogression or as senile re-adoptions of pre-adult and early characters; for the succession of *Dalmanites*-forms is traceable in practically a continuous and unbroken series from their first appearance to their extinction.

The loss of the original pentamerism of the head-shield to a greater or less extent, as illustrated by a large number of members of the family, must be taken as a departure from primitive conditions and as a sign of specialisation and an advance in development.

This structural change may take place in either of two ways, (1) by the fusion of two or more of the successive lobes; or (2) by the unequal growth of the lobes, leading to the reduction in size or squeezing-out of some of them. In the first case the obsolescence or complete disappearance of the segmental (lateral) furrows concerned accompanies the change; and in the second case the lobes themselves are more or less lost.

It is noticeable that these types of structure in the head-shield do not absolutely replace each other in regular chronological succession, but frequently exist contemporaneously; the more highly specialised type did not drive out the simpler type, and the old primitive stock from which the others must have been derived held its ground in spite of the vigorous growth of its lateral offshoots, even lasting till the final disappearance of the family.

A large number of intermediate conditions between the perfect pentamerous and the lobeless or paucilobed forms of Phacopidæ have been observed, and this has given rise to the abundant and varied nomenclature. Many of the so-called genera, subgenera, and groups or sections have been founded on these transitional forms, which are of much interest from a developmental point of view, but these distinctive names of higher than specific rank have obscured the broad features of the phylogeny, particularly in cases where the occurrence of such forms is purely local and their representation restricted to a single species.

The presence of so many intermediate links has rendered the division of the family into sharply separated and well-defined genera a matter of extraordinary difficulty, as the literature on the subject illustrates, hardly two authorities agreeing completely on the limits of the various divisions of the family.

Lines of Development.

Regarded as a whole we may distinguish three lines along which the development of the Phacopidæ has proceeded, and they start from an early stage in the history of the family. Two of these lines find their culmination in the Devonian period, where they are represented by the typical *Phacops* with a lobeless or nearly lobeless short glabella, and the specialised types of *Dalmanites* with an elongated well-segmented glabella. Hoernes[1] had traced the whole history of these two parallel branches of the family in Bohemia from the Ordovician to the Devonian, and has clearly shown that the typical *Phacops* is derived by a series of progressive changes from the primitive forms of *Dalmanites* which form the root of the whole family.

Along the *Dalmanites*-line a pentamerous segmentation of the head-shield with a more or less elongated cranidium and glabella have persisted, though the glabella has been occasionally modified by the unequal or irregular growth of the lobes, and even by the partial obliteration of some of the lateral furrows; the head-shield also has in some cases accompanied these changes by the production of various marginal or superficial ornaments or processes, but their development in other cases has been independent.

Along the other line there has taken place a general shortening of the cranidium, with a loss of segmentation occasioned by the obsolescence or disappearance of the lateral furrows of the glabella; the lobes have become more or less completely fused, the glabella inflated, and the outline of the head-shield generally rounded without any marginal processes.

Concurrent changes in the thorax and pygidium are also noticeable along each line.

In the *Dalmanites*-branch the thorax tends to become flattened, and to develop free-pointed ends to the pleuræ, while the number of the segments in the pygidium increases, and its extremity becomes mucronate, or the margin may be produced into various spinose processes. The general tendency to develop spines and processes on the head-shield and pygidium is a marked characteristic of the later members of this branch.

On the other hand, the *Phacops*-branch tends to have all points rounded off; the genal angles of the head-shield are usually rounded and not produced; there is an absence of spinose ornaments on the head; the thorax becomes more convex; the pleuræ have their ends obtuse or rounded; the pygidium is not elongated, but assumes a semicircular more or less transverse form without terminal or lateral processes, and consists of comparatively few segments. Hoernes traces the origin of this *Phacops*-branch from the primitive *Dalmanites*-forms (e.g., *D. socialis*, *D. Phillipsi*, etc.), and upwards through the Silurian group of *Phacops Glockeri* and its allies.

As we should expect from our knowledge of the ontogeny, the earliest members of the whole family have a pentamerously segmented head-shield. This is the case in Bohemia, as Hoernes notes, and also in England, where the earliest Phacopids are *Ph. Nicholsoni* of the Skiddaw Slates and *Ph. llanvirnensis* of the Upper Arenig (Llanvirn Beds).

The primitive *Dalmanites*-group may be therefore regarded as constituting the stock from which later groups have branched off,

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[1] Hoernes, Jahrb. Geol. Reichsanst. Wien, Bd. xxx, Heft 4 (1880), pp. 651–686: and id., Kosmos, Jahrg. iv, Bd. viii (1880), pp. 20–32.

and its characters are, as we should anticipate, somewhat composite and varied. The elements of future lines of development are found to be contained within its limits. For example, the genal angles are sometimes spined and sometimes rounded; the same is the case with the extremities of the thoracic pleuræ; the pygidium, though always consisting of fewer segments than in the *Dalmanites* of later periods, is in some species elongated and mucronate, while in others it is rounded and has a simple margin. Two sub-groups can in fact be distinguished in the Bohemian group of primitive *Dalmanites*, as Hoernes has pointed out: one sub-group marked by *D. Angelini* and *D. socialis*, leading onward into the typical Silurian *Dalmanites*, while the other, which comprises such forms as *D. atavus* and *D. Phillipsi*, has more in common with the later group of *Ph. Glockeri*.

Branch A.

In the case of the branch culminating in the spinose and otherwise ornamented representatives of *Dalmanites* of the Devonian period, there is no continuous chain of forms in Bohemia connecting the latest developments of the pentamerous series with the early stock. Étage E affords no evidence of the existence of this branch, and perhaps the scene of its evolution was temporarily moved elsewhere. In Northern Europe, and even in the British Isles alone, we are able to fill up this gap to some extent. For in England, succeeding the Arenig forms of early *Dalmanites*, we get a variety of *D. socialis* in the *Orthis argentea* shales of South Wales,[1] and in the Sholeshook and Redhill Beds we find *D. Robertsi*,[2] in which the characters are composite as in the Bohemian early stock. Then comes *D. appendiculatus*, Salter, of the Bala and Ashgill shales, possessing most of the features of a typical Silurian *Dalmanites*, though it has fewer segments in the pygidium. The Silurian formation follows with the type-species of *Dalmanites*, *D. caudatus*, and it is accompanied by numerous allied forms, *D. longicaudatus*, *D. Weaveri*, *D. obtusicaudatus*, etc. During the equivalent period in Bohemia there seems to have been a complete absence of Phacopidæ belonging to the *Dalmanites*-branch. Passing to Scandinavia, we find the Ordovician *D. mucronatus* (which is closely allied to the English *D. appendiculatus*) succeeded by *D. caudatus* and related species. The *Dalmanites*-group is also well represented in North America and in Australia in Silurian beds, and has recently been discovered in Burma. In the following Devonian period we meet with a great and varied development of this group. In most parts of Europe the spinose group of *Asteropyge* occurs, and less commonly the smaller groups named *Malladaia*, *Cryphina*, and *Probolium*. In Bohemia the Devonian representatives of *Dalmanites* resemble structurally the typical Silurian forms of other parts of Europe, except in an increased number of pygidial segments. The other groups seem in this part of Europe to be absent. A notable departure from the

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[1] Reed: Geol. Mag., Dec. V, Vol. I (1904), p. 383, Pl. XII, Fig. 2.
[2] Ibid., p. 106, Pl. V.

Silurian type of glabella is found in ***Malladaia*** by the partial loss or reduction of the third pair of lateral lobes.[1] ***Cryphina***[2] differs mainly from *Asteropyge* in the number and shape of the marginal pygidial spines, and ***Probolium***[3] is characterised chiefly by the possession of a long frontal rostrum on the head-shield, rudiments of which are found in Silurian species.

(*To be continued.*)

REVIEWS.

JAARBOEK VAN HET MIJNWEZEN IN NEDERLANDSCH OOST-INDIË. Drie en dertigste Jaargang, 1904. Wetenschappelijk Gedeelte: Geologie eines Teiles von West Borneo, nebst einer kritischen Uebersicht des dortigen Erzvorkommens, zusammengestellt von N. WING EASTON, Oberbergingenieur. Zu diesem Werke gehoeren: Ein Atlas und eine Mappe mit Microphotographien. Batavia, Landsdrukkerij.

YEARBOOK OF MINING IN THE DUTCH EAST INDIES. 33rd year, 1904. Scientific Part: Geology of a Part of West Borneo, with a critical review of its Ore Deposits, composed by N. WING EASTON, Chief Mining Engineer. To this work belong an Atlas and a Map with Microphotographs. Royal 8vo: pp. xv, 542, with folio Atlas of 11 coloured geological plates, 1 plate of sections, and 1 of fossils; also 120 microphotographs of Borneo rocks, on 21 plates, with explanatory text. Batavia: State Printing Office.

ABOUT two years since[4] we called the attention of our readers to the elaborate work of Dr. Molengraaff describing his geological explorations in Central Borneo; we have now before us another volume, somewhat more restricted in character, giving an account of the geology of a part of the Residency of West Borneo, which includes the Kapuas district and the territory to the north of it. Mr. Wing Easton, the author of the work, has been about fourteen years engaged, on the part of the Dutch Colonial Government, in mining and geological exploration in this extensive region, and, judging from his descriptions, its topographical and geological features are generally very similar to those of Central Borneo. The country is by no means an ideal one for geological investigation, for there are hardly any well-defined highways, land communication is carried on along narrow footpaths or tracks, often through dense forests, and rock exposures are, as a rule, only met with on the banks of streams. Moreover, the apparently entire absence of fossils in the older sedimentary rocks of Borneo, and their extreme rarity and limited distribution in higher strata, form a serious hindrance to the determination of the real stratigraphical sequence, and, failing these clues, the author falls back on similarity in lithological characters and the degree of disturbance as evidence of correlation.

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[1] Oehlert: Bull. Soc. Géol. France, sér. III, vol. xxiv (1896), p. 843, woodcut fig. 12.

[2] Id.: op. cit., sér. III, vol. xvii (1889), p. 758.

[3] Ibid., p. 763, pl. xviii, fig. 6.

[4] GEOL. MAG., Dec. IV, Vol. X (1903), p. 167.

The oldest sedimentary rocks in West Borneo are dark, hard lustrous clay-slates of considerable thickness, without any admixture of either sandstones or limestones. No fossils have as yet been met with in them. The beds are strongly folded. With the exception of the higher beds of the series, which are supposed to be of Lower Triassic age, these slates are regarded as Palæozoic. They probably correspond to the 'Old Slate Formation' of Molengraaff.

Next above the clay-slates, the rocks consist of micaceous shales and pyritous sandstones, frequently alternating. Associated with the sediments there are massive beds of quartz-porphyry and diabase. In one locality an undoubted Triassic fossil, *Monotis salinaria*, is present, and serves to mark the age of these rocks; also, in siliceous marls and in beds of tuff, Radiolaria occur.

Succeeding the Triassic there comes a series of deposits of shales, marls, sandstones, and occasionally limestones, frequently fossiliferous, belonging to the Jurassic period. The Lias is shown in one locality by the occurrence of *Harpoceras radians*; casts of *Perisphinctes* may indicate Middle or Upper Jura, whilst on higher horizons of the age of the Dogger there are shales and marls containing *Exelissa*, *Corbula*, *Astarte*, and *Protocardium*, in places sufficiently numerous to form a shell-breccia.

Nearly at the base of the Jurassic series, in the neighbourhood of Kendai, there are beds of siliceous shales and marls with a total thickness of about 450 metres, which are rich in Radiolaria, but with the exception of a cast of *Corbula* other fossils were not met with in them. Most of the commoner forms of the Radiolaria described by Hinde in Molengraaff's work were recognized by the author in these deposits, and he is enabled thereby to confirm the opinion expressed by Hinde that they are Jurassic in age. Mr. Wing Easton, however, calls in question the accuracy of Molengraaff's view of the oceanic character of these radiolarian rocks, and considers that they are of brackish-water origin, mainly, it would appear, on the ground that higher in the series they are overlain by thick beds of hard sandstones containing *Corbula* and other shells indicating shallow-water conditions.

Deposits of fine sandstones, tuffs, shales, and marls with Radiolaria, and accompanied by thick beds of diabase and propylite, are referred to the Lower and Middle Cretaceous. Fossils are rare and limited to one locality. Species of the Ammonite genus *Knemoceras* have been determined by Dr. Krause, and are regarded as Cenomanian in age; whilst two Gasteropods, *Itiera scalaris*, Vogel, and *Nerinea* sp., may be of Gault age.

Sedimentary deposits of Tertiary age have not been met with in this part of Borneo, but this period is represented by eruptive rocks, mainly of hornblende-andesite, hypersthene-andesite, and basalt; this last forms extensive surface beds and gigantic flows.

The mineral wealth of Western Borneo has been greatly over-estimated: neither coal nor petroleum has been found; cinnabar, copper, and lead exist in small quantities; iron, molybdenum, and bismuth are met with, but none of these metals can be worked at a profit. The alluvial gold-bearing deposits are now nearly exhausted; the author considers this gold to have been derived originally from the quartz-porphyry. The alluvial gravels have also yielded diamonds.

With the view of ascertaining if any clue could be found to the relative age of the various sedimentary rocks in Borneo, and for comparison with the eruptive rocks in other parts of the East Indies, the author undertook a thorough investigation of the structure of the various igneous rocks, tuffs, and breccias present in the region, and a detailed description, extending to 160 pages, is given of their microscopical characters. To facilitate comparison, 120 admirably rendered microphotographs representing the principal types of these rocks are given in a separate cover. The author has arranged them under the following groups:—(i) Basalt; (ii) Andesite; (iii) Propylite; (iv) Diabase-diorite; (v) Biotite-diabase with hornblende or olivine; (vi) Uralite and Epidiabase; (vii) Normal Diabase, undoubtedly Triassic; (viii) Diorite, Norite, and Gabbro; (ix) Quartz-porphyry; (x) Granite and Quartz-diorite; and also (xi) Breccias of eruptive rocks.

Further, we may mention the Atlas of 12 carefully-drawn and coloured geological maps and sections and one plate of fossils.

Mr. Wing Easton and his coadjutors merit our congratulations on bringing their arduous labours involved in the preparation of this work to a successful conclusion.

REPORTS AND PROCEEDINGS.

GEOLOGICAL SOCIETY OF LONDON.

I.—February 17th, 1905.—J. E. Marr, Sc.D., F.R.S., President, in the Chair.

ANNUAL GENERAL MEETING.

The Reports of the Council and of the Library and Museum Committee for the year 1904 were read. After premising that the Society continues to be generally in a flourishing condition, the Council stated that there had been a small decrease in the number of Fellows during 1904. The total accession of Fellows in the course of the twelve months under review was 44. During the same period, the losses by death, resignation, and removal amounted to 53. The total number of Fellows on December 31st, 1904, was 1,251.

The balance-sheet for that year showed receipts to the amount of £3,187 3*s.* 9*d.* (including a balance of £192 6*s.* 11*d.* brought forward from the previous year), and an expenditure of £2,777 16*s.* 2*d.*

The completion of vol. lx and the commencement of vol. lxi of the *Society's* Quarterly Journal was announced.

It was stated that rapid progress was being made with Mr. C. Davies Sherborn's manuscript Card-Catalogue of the Library; and, further, that Mr. Sherborn had undertaken to continue during the current year the preparation of the catalogue-slips for the International Catalogue of Scientific Literature.

In view of the approaching centenary year of the Society (1907) the appointment of a Committee was announced, to carry out the scheme suggested by Mr. H. B. Woodward for the publication of a record which should embody the history of the Society.

The Report of the Library and Museum Committee enumerated the extensive additions made to the Society's Library, and gave some details as to the Card-Catalogue.

The Reports having been received, the President presented the Wollaston Medal to Dr. J. J. Harris Teall, F.R.S., addressing him as follows:—

Dr. Teall,—The Council have unanimously awarded to you the Wollaston Medal, in recognition of the value of your researches concerning the mineral structure of the Earth, and particularly of your contributions to the science of Petrology generally, and more especially to our knowledge of the structure and composition of the rocks of the British Islands.

With regard to the nature of those researches I need add nothing: the published work of a Wollaston Medallist is familiar to the students of our science in all parts of the world, and will remain in evidence to enable the geologists of the future to appreciate its value.

But, although this Medal has been awarded to you for your researches, not on account of these alone are we proud of you.

When presenting to you the degree of Doctor of Science *honoris causa* in the University of Dublin last year, the Public Orator referred to you as "a man as dear to all for the kindliness of his nature as he is admired by all for the profoundness of his learning." Thanks to this kindliness of nature, you have ever placed your great stores of knowledge at the disposal of other workers. How much work we thus owe to you will never be known, for in helping others you have ever acted on the principle of not letting your left hand know what your right hand doeth; but were it known, I can safely aver that it would be found to have promoted researches concerning the mineral structure of the Earth, to so great an extent as to render you doubly deserving of this Medal.

Each one of your predecessors, in the high post which you occupy as Director of the Geological Survey of the United Kingdom, has received the Wollaston Medal, and we welcome its award to you, who, like them, have done so much to foster the friendly feeling which exists, and will, I trust, ever exist, between the members of that Survey and other geologists.

That it falls to my lot to hand you this Medal is a source of keen pleasure to me. It is now more than a quarter of a century since we first met in our college; and since then I have indeed profited greatly by your ever-ready help, and am pleased to take this opportunity of acknowledging it.

Dr. Teall, in reply, said:—

Mr. President,—To be enrolled on the list of recipients of the Wollaston Medal is, I need hardly say, an honour that I appreciate highly, and the pleasure that I feel is enhanced by the fact that my name will follow very closely upon that of Professor Rosenbusch, to whom I, in common with all other petrographers, owe so much. I am vividly reminded to-day of a personal visit that Professor Rosenbusch paid to me at Kew many years ago, of the kindly interest that he displayed in my early efforts in microscopic petrography, and of the encouragement that he gave me to pursue the study in which I had been initiated by my old friend and College tutor, Professor Bonney. I feel especially indebted to these two former recipients of the Wollaston Medal, and I am glad of this opportunity of expressing my feelings towards them.

I thank the Council of the Geological Society for the very great honour that they have conferred upon me, and you, Sir, for the very kind words with which you have accompanied the award.

The President then handed the Murchison Medal, awarded to Mr. Edward John Dunn, of Melbourne (Victoria), to Professor J. W. Judd, C.B., F.R.S., for transmission to the recipient, and addressed him in the following words:—

Professor Judd,—The Murchison Medal has been awarded to Mr. E. J. Dunn in recognition of his valuable contributions to geological science by the preparation of his geological maps of South Africa and his investigations concerning the occurrence of gold in Australia.

Mr. Dunn's career furnishes the world with an admirable proof, were such needed, of the value of the economic application of our science. Naturally attracted to the science, Mr. Dunn fitted himself for the pursuit of the special branch with which he has been most closely connected, by study at the Royal School of Mines. Although his attention has been chiefly directed to gold-bearing rocks in Africa and Australia, he has not neglected branches of geology unconnected with economics, and has in particular contributed to our knowledge of Glacial deposits in different parts of the world. His labours in mapping portions of South Africa rendered him eminently qualified for the post to which he has now been called—the Directorship of the Geological Survey of Victoria.

Considering the great interest which the founder of this Medal took in the geological conditions which have controlled the distribution of gold, the award of the Murchison Medal to Mr. Dunn is peculiarly appropriate.

In conveying it to him, will you also wish him on our behalf a successful career in his new office, and remind him that the geologists of this island watch with interest and satisfaction the labours of their brethren in Greater Britain.

Professor Judd replied as follows:—

Mr. President,—I regret that the period since the award of this Medal by the Council has not permitted of our receiving a reply to the announcement made to Mr. Dunn at Melbourne. I do not doubt, however, that, on his behalf, I may assure you of the sense which he entertains of the honour that has been conferred upon him by the award of the Murchison Medal. Thirty years have elapsed since Mr. Dunn made his first contributions to this Society, upon the then little-known geology of South Africa; and, during more than thirty years, he has laboured unweariedly in solving geological problems in our Colonies—first in South Africa, and afterwards in Australia. Besides the gratification given to the recipient himself, I feel assured that this award—made by the mother of geological societies to one so closely identified with the progress of our science in the Colonies—will be regarded by them as an act not less graceful than just. It will serve to convince those young and vigorous communities of our sympathy with, and interest in, their efforts to explore the geological features of the vast areas of the Earth's surface which constitute their heritage.

In handing the Lyell Medal, awarded to Dr. Hans Reusch, F.M.G.S., Director of the Geological Survey of Norway, to Sir Archibald Geikie, Sc.D., Sec. R.S., for transmission to the recipient, the President addressed him as follows:—

Sir Archibald Geikie,—The Lyell Medal is awarded to Dr. Hans Reusch, as a mark of honorary distinction and as an expression on the part of the Council that he has deserved well of the science, particularly by his contributions to our knowledge of the geology of Norway.

Born on that "fragment of primeval Europe" extending through Scandinavia and Caledonia, which has been the training-ground of so many geologists of eminence, Dr. Reusch has zealously pursued the study of our science in his native land. Undeterred by the difficulties which beset the students of its rocks, and avoiding the pitfalls of hypothesis, he has garnered a store of information which is of very high value to the students of the crystalline schists. Nor has he confined his attention to

these rocks, but has added to our knowledge of the glacial phenomena of his country, and of recent years especially has been attracted by the fascinating task of accounting for many of its surface-features.

The reception of the Medal by you, Sir, on Dr. Reusch's behalf but partially diminishes our regret at his absence this day. In conveying the Medal to him, will you at the same time convey the good wishes of the many workers in this country who are glad to number him among their friends.

Sir Archibald Geikie, in reply, said:—

Mr. President,—It gives me great pleasure to be the medium of transmitting the Lyell Medal to my old friend Dr. Hans Reusch. No one who is familiar with the progress of geology in Scandinavia during the last quarter of a century can have the least hesitation in cordially approving the action of the Council in conferring this distinction upon him. He has thrown light on the oldest rocks of Norway and on the problems of metamorphism, and he has included the youngest geological phenomena within his ken. Having had the advantage of making traverses of his ground with him in the north of Norway, I can bear witness to his keen powers of observation, and to the enthusiasm with which he employs them. We may hope that many years of active work are still in store for him, to the great advantage of our science. Dr. Reusch, in asking me to receive the Medal on his behalf, has enclosed a few words of acknowledgment, which I will now read:—

"It is to me a great and unexpected pleasure to receive the Lyell Medal from the Council of a Society so celebrated throughout the scientific world.

"It is the case with me, as with so many others, that the name of Lyell is allied with our earliest interest in the science dear to us all. I remember well, though I have not seen it for a good many years, the old copy of the first German translation of the 'Principles,' borrowed, when I was a boy, from the Museum in my native town of Bergen, and how I read in it with wonder of the evolution of the very earth that we are wandering upon.

"In later years, during the 'seventies,' when I was a student, the stout volumes of the 'Quarterly Journal' in the University Library in Christiania were always of the greatest interest to me, as they appeared year by year; and it was a memorable day of joy to me when the news arrived that I had myself the honour of being elected a Member of the Geological Society.

"My work in the days left to me will be, I hope, in my native land of Norway. As your Society embraces the whole world in its survey of our science, it is my hope that such small sparks of truth as I may be able to add to what is known of the geology of Norway may be of some small interest to your Members. I return my heartiest thanks to the Council of the Geological Society for the great and undeserved honour which they have bestowed upon me."

The President, in presenting the Bigsby Medal to Professor John Walter Gregory, D.Sc., F.R.S., addressed him in the following words:—

Professor Gregory,—The Bigsby Medal is awarded to you, as an acknowledgment of your eminent services to Geology, the result of work carried on in many parts of the world.

The founder of this Medal was himself a traveller. In the preface to his book "The Shoe and Canoe," he tells us that he spent six happy years wandering over the greater portion of the Canadas. He also did good service by his work in the study, as shown by his "Thesaurus Siluricus" and "Thesaurus Devonico-Carboniferous." Could he extend his hand across the gulf, I feel that he would give a warm welcome to one who has earned this award by work in the study and the museum, and by explorations carried out in many lands, exposed at times to the scorching sun of Africa, at others to the icy blast of Arctic climes.

Worthy indeed are you to receive this Medal, which in the terms of the Bequest is to be awarded "as an acknowledgment of eminent services in any department of Geology," for we acknowledge your services in all departments of that science.

Professor Gregory replied as follows:—

Mr. President,—It is impossible adequately to express my thanks to the Council for the honour of this award, and to you, Sir, for the very kind words with which you have presented it. My only regret in connection with this Medal is that, owing to your many years of devoted service to the Society as its Secretary, your name does not appear on the roll of my predecessors.

The list of my contributions to geological literature includes a somewhat wide range of subjects, to which you have referred very kindly, although they may appear sadly disconnected. Of course, every geologist who is not master of his own time must devote most of his energies to work not of his own selecting. He must do what he should, and not what he would. I owe it to the sympathetic consideration with which the senior officials of the British Museum treat their assistants, that much of my work when I was on its staff had as close a bearing as it had upon the problems in which I have been most deeply interested. My attention was first directed to geology in order to understand the geography of the districts through which I rambled, and the often apparently erratic course of the rivers. The bent that led me into geology, in order to understand local topography, subsequently roused my especial interest in the existing plan of the Earth. That interest has caused me to spend so much of my vacations collecting evidence in the 'back-blocks' of the Earth, that I have not yet had sufficient opportunity to work out the results. This award will justify an attempt to secure more time for this work. One of the favourite proverbs of one of my old Zanzibar porters was 'Whither good things go, thence good things should return.' The words of Bigsby's will show that this maxim inspired his bequest; and I am bound to make as good a return to our science as I can for this valued Medal, and for the good wishes and cheering confidence which it betokens.

In presenting the Balance of the Proceeds of the Wollaston Donation-Fund to Mr. Henry Howe Arnold-Bemrose, M.A., the President addressed him as follows:—

Mr. Arnold-Bemrose,—The Council have awarded the Balance of the Proceeds of the Wollaston Donation-Fund to you, as an acknowledgment of the value of your investigations among the igneous and other rocks and the cave-deposits of Derbyshire.

In the intervals of a busy life you have done much to add to our knowledge of the geology of that county, and have also generously placed your services at the disposal of geologists visiting the district. We look forward with confidence to further work from your pen, and hope that you will receive this award as an encouragement to you in carrying on your labours.

The President then presented the Balance of the Proceeds of the Murchison Geological Fund to Mr. Herbert Lister Bowman, M.A., addressing him in the following words:—

Mr. Bowman,—There appeared at one time to be some danger that Mineralogy might be divorced from Geology. This Society has never ceased to recognize the relationship of the two sciences, and the Council acknowledge it on this occasion by awarding the Balance of the Proceeds of the Murchison Geological Fund to you, who are pursuing the study of the former science. The Council moreover hope that this award may encourage you to prosecute further those researches in which you are already so far advanced,—researches in a science the study of which has received so great an impetus in your University by the labours of the distinguished occupant of the Waynflete Chair of Mineralogy.

The President then presented a moiety of the Balance of the Proceeds of the Lyell Geological Fund to Mr. Edward Alexander Newell Arber, M.A., addressing him as follows:—

Mr. Arber,—The Council have awarded a moiety of the Balance of the Proceeds of the Lyell Geological Fund to you, in recognition of your valuable contributions to our knowledge of Palæobotany.

In addition to the papers which you have contributed to this Society, I would specially refer to the paper on "The Fossil Flora of the Culm-Measures of North-West Devon," printed in the Philosophical Transactions of the Royal Society.

I hope that you will regard this award as an encouragement to further work. Let me assure you of the pleasure which it gives me to hand it to a former pupil and present colleague.

In presenting the other moiety of the Balance of the Proceeds of the Lyell Geological Fund to Mr. Walcot Gibson, B.Sc., the President addressed him as follows :—

Mr. Walcot Gibson,—A moiety of the Balance of the Proceeds of the Lyell Geological Fund is awarded to you as an acknowledgment of the valuable work done by you among the Carboniferous and other strata of the Midland counties, as well as among the auriferous and associated rocks of South Africa, and as an encouragement to further research.

While pursuing your calling as a Geological Surveyor, you have been ever on the alert to utilize what has been written concerning the rocks which you mapped, and also to record your own observations, with results beneficial alike to the Survey and to the science.

The President then proceeded to read his Anniversary Address, giving first of all obituary notices of several Fellows deceased since the last annual meeting, including General C. A. McMahon (elected a Fellow in 1878), Sir Clement Le Neve Foster (el. 1863), Mr. F. Rutley (el. 1870), Mr. R. F. Tomes (el. 1877), Mr. R. H. Valpy (el. 1862), Mr. W. Ferguson (el. 1854), the Rev. H. Brass (el. 1857), Dr. C. Ricketts (el. 1867), Mr. T. W. Shore (el. 1878), the Rev. H. P. Gurney (el. 1877), Mr. F. McClean (el. 1863), Dr. I. Roberts (el. 1870), and Mr. R. M. Browne (el. 1867); also of Professor F. Fouqué (el. For. Memb. 1889) and of Dr. C. E. Beecher (el. For. Corr. 1899).

He then proceeded to call attention to the Classification of the Sedimentary Rocks, pointing out that the arrangement of the events which, taken together, constitute Earth-history, according to their proper sequence in time must ever remain the territory of the geologist in which he will pursue his labours by exclusively geological methods.

He pointed out that, since the time of William Smith, and mainly by the adoption of his principles, the classification of the strata had progressed towards perfection by the method of successive approximations.

He drew attention to the many similarities between the records of the geological column and the records preserved in the 'meteorograms' of meteorologists. In each case the records were impressed as zigzag and broken lines, though an additional difficulty occurred in the case of the geological records owing to their frequently blurred nature.

Further, the meteorologist had his chronometer, whereas the geologist must construct his time-scale from the records on what might, for purposes of comparison, be referred to as the 'geograms,' or strips of the geological sediments. In some cases the lines of the geograms closely coincided with time-lines, in other cases they departed therefrom more or less widely, and it was one of the tasks of the geologists, from study of the geograms, to attempt to draw in the time-lines.

It was to be remembered, however, that however closely the time-lines and lines of the records coincided, they were not the same lines.

The President drew attention to the principal variations in the records of the geograms, due to alternate formation and cessation of deposit; to the differences in character of the deposits owing to various local conditions; to accumulation of contemporaneous volcanic material; to variations in the nature of the earth-movements; to changes in the nature of the included organisms; and lastly to climatic changes, and proceeded to consider the significance of these records as bearing upon the classification of the sediments.

He advocated the adoption of a triple classification, such as had been already tacitly adopted in the case of some of the sediments, as, for instance, those of Jurassic age, where divisions were made according to (i) lithological change, (ii) organic change, and (iii) time; and pointed out how such a classification could be adopted without any violent changes in an existing nomenclature or in the rules of priority.

He illustrated the suggested changes by a more detailed discussion of the classification of the Ordovician strata, and pointed out that we had names which might be used with chronological significance in the case of the divisions of the rocks of most of the great systems; and maintained that, as our knowledge increased, we could refer beds of new areas to their places among the different series marking periods of time with a confidence similar to that with which we have long assigned strata of remote regions to one or other of the great systems.

The ballot for the Council and Officers was taken, and the following were declared duly elected for the ensuing year:—*Council:* F. A. Bather, M.A., D.Sc.; W. T. Blanford, C.I.E., LL.D., F.R.S.; Professor T. G. Bonney, Sc.D., LL.D., F.R.S., F.S.A.; Sir John Evans, K.C.B., D.C.L., LL.D., F.R.S.; Professor E. J. Garwood, M.A.; Sir Archibald Geikie, Sc.D., D.C.L., LL.D., Sec.R.S.; R. S. Herries, M.A.; Professor J. W. Judd, C.B., LL.D., V.P.R.S.; Professor Percy F. Kendall; Philip Lake, M.A.; Professor Charles Lapworth, M.Sc., LL.D., F.R.S.; Richard Lydekker, B.A., F.R.S.; Bedford McNeill, Assoc. R.S.M.; J. E. Marr, Sc.D., F.R.S.; Professor H. A. Miers, M.A., F.R.S.; H. W. Monckton, F.L.S.; F. W. Rudler, I.S.O.; L. J. Spencer, M.A.; Aubrey Strahan, M.A., F.R.S.; C. Fox Strangways; Professor W. W. Watts, M.A., M.Sc., F.R.S.; the Rev. H. H. Winwood, M.A.; and H. B. Woodward, F.R.S.

Officers:—President: J. E. Marr, Sc.D., F.R.S. *Vice-Presidents:* Professor T. G. Bonney, Sc.D., LL.D., F.R.S., F.S.A.; R. S. Herries, M.A.; Professor Charles Lapworth, M.Sc., LL.D., F.R.S.; and H. B. Woodward, F.R.S. *Secretaries:* Professor E. J. Garwood, M.A., and Professor W. W. Watts, M.A., M.Sc., F.R.S. *Foreign Secretary:* Sir John Evans, K.C.B., D.C.L., LL.D., F.R.S., F.L.S. *Treasurer:* W. T. Blanford, C.I.E., LL.D., F.R.S.

II.—February 22nd, 1905.—J. E. Marr, Sc.D., F.R.S., President, in the Chair.

Dr. F. A. Bather exhibited a series of Danish rocks[1] illustrating:

(1) The share that Echinoderms may take in rock-building;

(2) The transition from the Secondary to the Tertiary Era in the Baltic basin near Denmark;

(3) The special conditions at the close of the Glacial Period, in the limited area where alone these rocks are now found as erratic blocks.

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[1] The rocks have been described in papers by K. A. Grönwall: Danmarks geol. Undersög. II, Række, No. 15; Medd. Dansk geol. Foren., vol. x, p. 1; and Jahrb. Preuss. geol. Landesanst., vol. xxiv, p. 420—all in 1904. Also by W. Deecke, *Mitth.* naturwissench. Ver. Neuvorpommern, vol. xxxi (1899), p. 67.

The specimens comprised:— (*a*) Fragment of a boulder from the Free Harbour of Copenhagen, consisting of rock from the zone of *Crania tuberculata*, and containing many unrolled echinoderm fragments; it appears to have been formed in shallow water; (*b*) fragment of a boulder from Langeland, consisting of rock of Palæocene age, and containing rolled fragments of Cretaceous echinoderms with shells of Tertiary molluscs; (*c*) fragment of a similar boulder, showing signs of further detrition; (*d*) fragment of a boulder from the island of Rügen, with echinoderm fragments still more rolled. All these rocks appear, from the distribution of the boulders, to have been deposited in a basin of the Baltic between Scania and the islands of Rügen and Bornholm, where the Palæocene sea was shallower than on the west of Denmark.

The following communications were read:—

1. "On the Order of Succession of the Manx Slates in their Northern Half, and its Bearing on the Origin of the Schistose Breccia associated therewith." By the Rev. John Frederick Blake, M.A., F.G.S.

The author first describes a section where the Barrule Slate, the Snaefell Laminated Slate, and the Agneash Grit follow in descending order, dipping north-westward. The last-named is markedly laminated. The ascending series, by dip, is again repeated after a fault, and at Tholt-y-will the Schistose Breccia appears near or at the top. The best sections of the latter for stratigraphy are in Glen Auldyn and Sulby Glen. The Schistose Breccia is therefore taken as an additional upper member of the series.

General Distribution of the Manx Slates.—The Agneash Grit in Maughold Head is nearly vertical, and is followed by the Snaefell Laminated Slates. The height to which the Barrule Slates attain diminishes from east to west. The Schistose Breccia depends on the presence of those slates; its occurrence is noted in four areas to the west of the Barrule Slates, which are repeated by faults.

The position of the Lonan and Niarbyl Flags is indicated by two colours on the map. The Lonan Flags, etc., are never seen underlying the Manx Slates, but they overlie the earlier Manx Slates in the lower country near Maughold, near Sulby Glen, and north of Peel. They may, therefore, be called the Sulby Glen Series.

Characters and Origin of the Schistose Breccia.—Professor C. R. Van Hise gives three criteria for autoclastic rocks, with none of which do the Schistose Breccias agree, namely, the fragments of an autoclastic rock must be derived from the adjacent material; whether they be below or above; and the rock itself may be traced into an ordinary brecciated rock. The fragments examined do not agree with this statement. The rocks are not truly conglomeratic—some are too soft, or others too hard.

Examples at Ballaneary and elsewhere occur, of true autoclastic rocks, showing contrast.

2. "On the Wash-outs in the Middle Coal-measures of South Yorkshire." By Francis Edward Middleton, F.G.S.

In the neighbourhood of Aldwarke and Thrybergh extensive workings have proved that wash-outs have occurred at various horizons in the Middle and Lower Coal-measures, and the limits of certain of these have been accurately laid down on plans.

Denudation in the Barnsley Seam has been found over an area 1,700 yards in length from east to west, and in the Parkgate Seam (240 yards below) over an area 2,600 yards long from north to south. In neither case was the wash-out completely crossed, but its width cannot be less than 600 yards. The Swallow-Wood Seam, lying 60 yards below the Barnsley and above the Parkgate Seam, has been partly worked under the same area; but no signs of a wash-out have been found.

The opinion of the author is that the wash-outs occupy the sites of winding streams, meandering through the alluvial tracts in which the coal-seams were being formed.

CORRESPONDENCE.

FIVE THEORIES OF THE DEVON SCHISTS.

SIR,—Your reviewer has perhaps been unduly, and doubtless unintentionally, severe on the whole army of martyrs who have sacrificed themselves on the altar of the Devonshire schists during the past sixty-eight years. He hopes that mere hypothesis will soon give way to a more reasonable and probable interpretation of the facts. But, in truth, there has been but little hypothesis; though we undoubtedly have several elaborate theories, based on evidence much of which has seemed to eminent men worth consideration. We have had, for instance, the following distinct lines of argument:—

1. The schists are Upper Devonian, based on a certain interpretation of the anticline at Mudstone Bay, near Berry Head, and other stratigraphical facts.
2. The schists are Archæan, based on elaborate microscopical observations backed by great experience.
3. The schists are Devonian, based on a comparison of the slates, sandstones, and volcanic rocks between Scabbacombe Sands and Stoke Fleming with the schists between Hall Sands and the Prawle Point.
4. The Start schists are Lower Devonian, based on a comparison of the microscopical composition, character, and fineness of grain of the quartz-schists with those of the Lower Devonian thin-bedded sandstones.
5. The schists are older than Devonian, but not necessarily Archæan. The positive arguments in favour of this view I do not fully grasp.

Curiously enough, the authors of the Memoir, in their list of literature, have missed a most important paper, viz. "The Metamorphosis of the Rocks extending from Hope Cove to Start Bay," by W. Pengelly, F.R.S. (Trans. Dev. Assoc., 1879). This paper is very important as a summary of the current opinions then held by *geologists.* The Upper Devonian age of the schists was treated as an almost trustworthy working hypothesis from which to deduce the 'era of transformation.'

No doubt the earlier geologists misinterpreted the stratigraphy of South Devon, and therefore their theory broke down; but it was a very elaborately argued theory, and was by no means a hypothesis.

The Archæan doctrine of the schists is also a true theory, based on innumerable observations.

Mr. Somervail's view (No. 3) inferred the contemporaneity of the schists with the Scabbacombe-Stoke Fleming rocks; but the age of the schists will follow the age determined for the said rocks. There is nothing approaching a hypothesis in the argument.

No. 4, for which I am responsible, is based on a study of sediments, and is independent of both petrology and stratigraphy. It was at first based on a comparison of two specimens of thin-bedded sandstones with a specimen of a quartz-schist west of the Start. I first advanced it in a paper to the British Association in 1891; contending that the sandstone being Devonian the schist was Devonian too. This, however, committed me to it being also Lower Devonian.

In its then early stage this view was no more than a working hypothesis, advanced before the Survey attacked the schist district on its own account. It was a friendly challenge to my friends to upset me if they could. But, strange to say, they never succeeded in doing so, neither stratigraphically nor petrologically. My view has now attained the unexpected dignity of a theory, and has actually survived fifteen years' hostile criticism, and the accumulation of an immense mass of fresh information. However, it was never a mere hypothesis, as the facts, though few, were undoubted.

Until the publication of the Memoir there was one very weak spot in my armour. I had entirely failed to trace the albite granules of the schists into the Devonian rocks. Now that the quartz-felspar veins, abundant in both series, have been proved to be quartz-albite, that missing link is unexpectedly connected.

The view No. 5 was first advanced by Mr. Hudleston, F.R.S., in his address to the Devon Association, and has since been adopted by Mr. Lowe, F.G.S., and is apparently accepted by your reviewer. It is equally subversive of all the others, whether based on petrology, stratigraphy, or sediments. My contention that Nature will never exactly reproduce in the same spot Archæan conditions in Devonian times, is almost equally cogent against her reproducing Cambrian or Silurian conditions. As my argument is that the rocks in question (the quartz-schists) are Lower Devonian, and is not that these rocks are not Archæan, Cambrian, or Silurian, any of these latter alternatives is equally fatal to theory No. 4. Were I to be ousted from No. 4 I should return to my former allegiance to Professor Bonney. However, during the past fifteen years I have not been favoured with a scrap of evidence against my Devonian theory from the sediment point of view, and, so far as I can ascertain, there is no petrological or stratigraphical fact in hopeless conflict with it.

There is one point I may perhaps mention. Although the Torcross volcanic rocks are very inconsiderable, the Scabbacombe-Stoke

Fleming rocks are very important, both on shore and at sea. The islets of the Mewstone, Eastern Blackstone, and Western Blackstone are all volcanic. The Mewstone, with its southern mass of diabase abutting on its northern vertical slates, is as like the green 'schist' and mica-schist at the Start as a raw egg is to a boiled one; and I fully believe their relations are very similar thereto. A. R. HUNT.

CAVITIES IN CRYSTALLINE ROCKS.

SIR,—I notice in the February number of the GEOLOGICAL MAGAZINE a letter from Professor Bonney on the subject of atmospherically eroded rocks. In this connection it may be of interest to put on record the fact that hollowed rocks, apparently quite like those described by Mr. Tuckett, Professor Bonney, and the Rev. R. Baron, were met with under totally different atmospheric conditions in the Antarctic. The examples there also occur in granite. They are found at an altitude of about 4,000 feet in latitude 77° 49′ S., longitude 163° E., in South Victoria Land, and at least two types may be distinguished.

A. In fairly normal granite. The rock is a very ordinary grey to pink granite with felspars usually about a quarter of an inch long; it appears to be quite fresh even on the surface, and has a marked superficial glaze on both convex and concave surfaces. The most striking cavity is on the south and weather side of a large block, and therefore faces away from the sun; it is about eighteen inches across at the opening, and the diameter increases inwards to at least two feet. The depth of the cavity is a little more than a foot, and the back wall is partially covered with a hard mammillated or botryoidal crust, the surface of which is white and harsh to the touch. Pieces of this were brought home, and some of these Mr. Prior has kindly analysed for me: he says, "the incrustation consists mainly of carbonate of lime; there is a little silica left behind on solution in hydrochloric acid." The incrustation was lamellar, scarcely more than one-eighth of an inch thick on the average, but in the projecting botryoids, which are sometimes partially hollow, may be more. The incrustation was firmly fixed to the granite face, and it was impossible to make out whether the surface beneath it was or was not glazed.

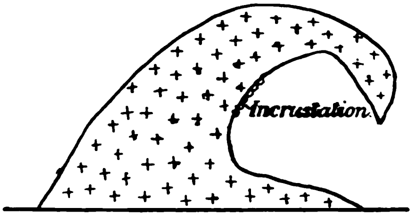


FIG. 1.—A large block of granite showing cavity on the south and weather side; 18 inches across at opening, diameter increasing to 2 feet inwards; depth of cavity more than a foot.

B. In a very coarse granite with abundant large crystals of orthoclase. The hollowed blocks are rounded, but owing to the rapid disintegration which the surface is undergoing it is roughened rather than glazed. The largest cavity is in a block 6 by 4 by 4 feet, which is hollowed almost to a shell. The cavity is four feet long, three feet deep, and two feet high, and has four apertures varying from a foot to eighteen inches in diameter, and corresponding in position to the centre points of the four sides of the original block. The lip of the apertures is exceedingly sharp, and the solid angle is certainly not greater than 30°. No incrustation was seen on the walls of this cavity, but on the floor is a sprinkling of the finer disintegration products of the granite which abundantly litter the surrounding area.

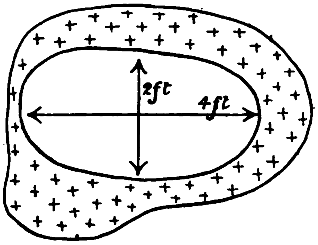


Fig. 2.—Cavity in a block of very coarse granite, 6 × 4 × 4 feet. The cavity is 4 feet long, 3 feet deep, and 2 feet high, and has four apertures varying from a foot to 18 inches in diameter, one on each side of block.

From this brief description it will be seen that the former type of Antarctic granite cavities closely resembles in shape and in superficial glaze the cavities described in Corsica and in Madagascar. As in Corsica, many saucer-like depressions and a few potholes were observed, and seem to mark stages in the development of the completed cavities. Internal incrustations do not seem to be recorded, but Mr. Baron mentions a "white powder alkaline to the taste" as occurring in the hollowed blocks of Madagascar.

Sidney Sussex College, Cambridge. H. T. Ferrar.
February 18*th*, 1905.

THE PROSPECTORS' PAN.

Sir,—May I be allowed to point out the advantages to be derived by the use of the prospector's pan as an aid to research in geology? Everyone interested in the subject is, of course, aware that minerals of economic importance may be traced to their original sites by successive pannings taken from the alluvium of a stream at points successively nearer to the source, due attention being paid to the incoming of tributaries; but the method is not in common use by the geologist.

The gold pan treats some 25 lbs. of medium gravel, containing small boulders, at one time, and the operation of panning can of course be stopped at any stage desired so as to include or exclude such minerals as tourmaline and hornblende. I would suggest that for investigations into the mineralogical composition of glacial deposits and the more compacted sediments this method of panning might be tried. In dealing with a hard rock, pounding in a mortar and the proper use of sieves of various meshes may be necessar before panning. The method is rapid, gives reliable quantitati results, and deals with larger quantities than are convenient by mo refined means.

Pan concentrates derived from any given crystalline rock becon readily recognizable after a short time, and in forested country, whe little or no rock is visible, afford a valuable guide in rough mappin That, at least, is my experience in Southern Nigeria.

CALABAR, W.C.A.
January, 1905.

JOHN PARKINSON.

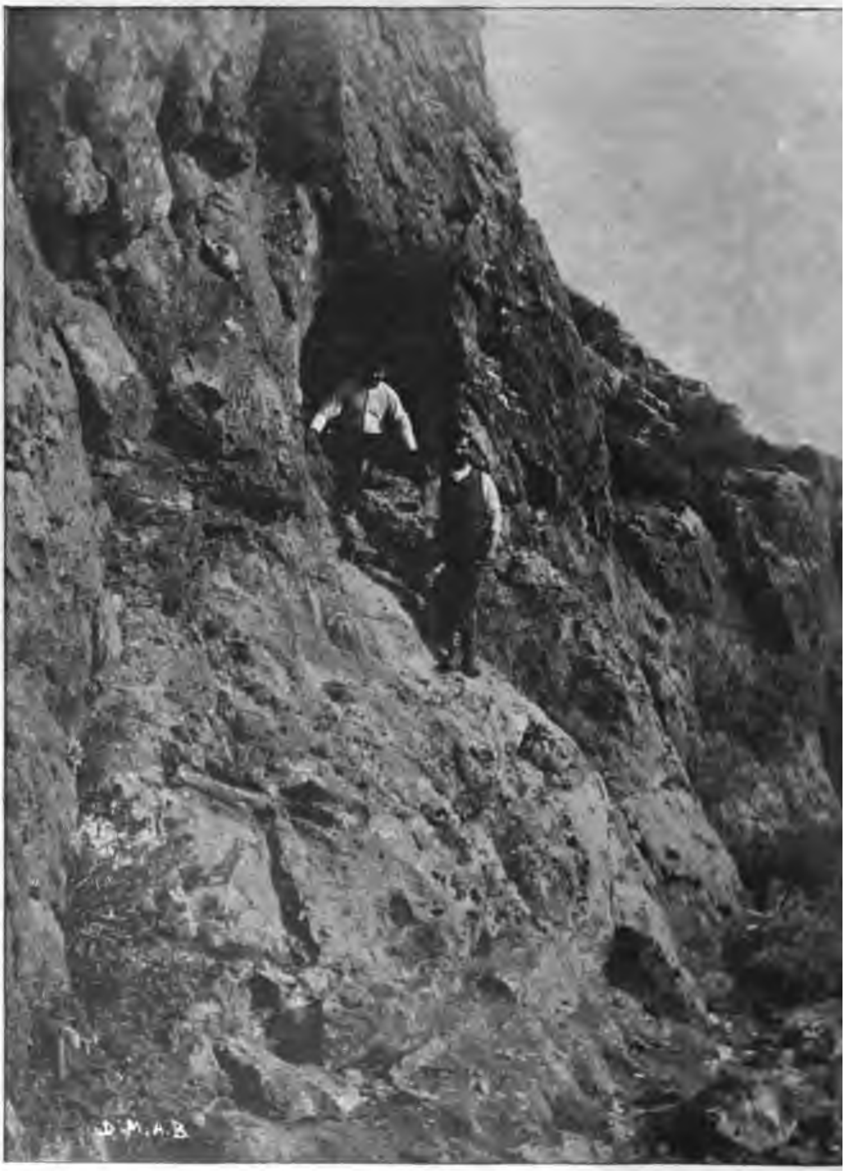
OBITUARY.

JEREMIAH SLADE, F.G.S.

BORN JULY 19, 1828. DIED MARCH 9, 1905.

IT is with much regret that we record the death, at the age of 7 of Mr. J. Slade. Although not known to scientific workers b published researches he had for half a century been a strenuou teacher and a helper to others. Brought up to the business c a coachbuilder in St. John Street Road, London, he was enable comparatively early in life to retire, and devote his whole attentio to natural history. While resident in the north of London he wa a supporter of the once flourishing Literary and Philosophica Institution in Islington, and a frequent attendant at Dr. Bowerbank' "Monday Evenings at home" in Highbury Grove. He was earl connected with the Working Men's College in Great Ormond Street and it was at that institution in 1858 that the formation of th Geologists' Association was first discussed. Among those who too part in the provisional committee and who became founders of th Association were the Rev. T. Wiltshire, Mr. George Potter, Mr. Toulmi Smith, Mr. E. Cresy, Mr. W. Hislop, Mr. J. E. Wakefield, Mr. G. S Penson, and Mr. J. Slade. In 1866 Mr. Slade assisted in th formation of the North London Naturalists' Club, the earliest field club devoted to the study of natural history in the neighbourhoo of London, and of which he was chosen Secretary. For twent years (1865–85) he was a teacher of geology, mineralogy, zoolog and botany at the Working Men's College, the Birkbeck Institution and the City of London College. During this period, from 1870 to 1875 he studied at the Royal School of Mines. He was an active membe of the Quekett Microscopical Club, and he became a Fellow of th Geological Society in 1874. A constant attendant at the excursion of the Geologists' Association, his extensive and accurate informatio on many subjects, and his knowledge of plants especially, were eve cheerfully and unostentatiously communicated to inquiring students The only printed paper contributed by him to the Associatio was entitled "Notes on the Microscopic Structure of the Basal of Swallow Cliff and Uphill" (Proc. Geol. Assoc., vol. vii, 1881 pp. 112, 113). His services to science are not recorded on paper but they have borne good fruit and will long be remembered b a circle of friends whose love of Nature has been inspired an cultivated by his disinterested labours.

H. B. W.



Tripiti Cave, near Gonia Monastery, West Crete.

THE

GEOLOGICAL MAGAZINE.

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No. V.—MAY, 1905.

ORIGINAL ARTICLES.

I.—FOUR AND A HALF MONTHS IN CRETE IN SEARCH OF PLEISTOCENE MAMMALIAN REMAINS.

By DOROTHEA M. A. BATE.

(PLATES IX AND X.)

THE geological map of Crete shows that a large portion of the island is composed of ancient limestone, in itself almost a guarantee of the presence of Pleistocene cave deposits. In confirmation of this, Admiral Spratt in his most valuable work[1] mentions finding two such deposits, from one of which he obtained a few mammalian remains.

I arrived off Khania early one morning in the beginning of March, 1904. From the sea the town is picturesque, being built down to the water's edge and almost encircling its tiny harbour. At some distance inland the Aspro Vouno rise abruptly in places to a height of 8,000 feet; this massive ridge forms the backbone of the western district, the wildest and most rugged part of mountainous Crete. At this time of year the snow lies for a considerable distance below the topmost summits, and it is not until months later that it disappears, leaving, as on Ida, a few patches on sheltered slopes and in deep crevices, where it remains the whole year round.

Roughly speaking, Crete may be said to consist of a high and central limestone ridge, at the foot of which is a border of fertile country. In three places this fertile zone extends across the entire width of the island, separating this backbone into four more or less isolated masses. These are the Aspro Vouno and the Mount Ida group, which are more closely connected than the other divisions, the Lassethe Mountains and the hilly plateau of Sitaea. It is curious to note that differences exist, both in language and dress, between the inhabitants of these several parts of the island. The limestone formation reappears as a somewhat broken fringe along the coastline round almost the entire island. In early days these limestone mountains and hills existed as a group of islands set in a Neogene sea, represented nowadays by the low and cultivated areas.[1]

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[1] "Travels and Researches in Crete," 2 vols.; London, 1865.

WESTERN CRETE.

Khania being my headquarters, excursions were made to various places in the near vicinity, including Akrotiri, a peninsula of considerable size edged with limestone cliffs, which at its north-eastern extremity attain to a considerable height. This is more especially the case between Cape Tripiti and the village of Khoridaki, above which rises a hill of 1,745 feet; the cliffs descend almost perpendicularly to the sea, and in a few places are pierced by narrow, winding gorges. A good deal of this tract of country was examined at different times, and the results will be noticed here.

The first deposit found is believed to be the one mentioned by Admiral Spratt[2] between Khania and Suda. It lies close to the pathway between these two places, and at the edge of the limestone forming the base of the Akrotiri at the point where it joins the fertile plain of Khania, by which it is separated from the outlying spurs of the Aspro Vouno. The limestone is very much weathered, and only in one spot is there any roof above the fragmentary mammalian remains still to be seen. These occur here and there for a distance of about 40 yards, and appeared to consist chiefly of bones of a ruminant. Besides this some fragments of breccia were obtained which contained bones and teeth of some small rodents and of a shrew.

Raulin,[3] quoting from Pococke, describes the ruined village of Saint George, in the Akrotiri, in which there was a church built in a double-chambered cave said to contain petrified bones "plus gros qu'à l'ordinaire," this traveller himself seeing some in the softer parts of the rock in the outer chamber. It was a long time before this deserted village was found, it being now almost forgotten by the peasants of the district. I was eventually guided to it by a man from Khoraphakia, to whom it was known as Galagatho. It lies concealed among the hills at the back of the ridge rising above Cape Tripiti, and is reached by an extremely rough path, which most of the way is also the rocky bed of a mountain torrent. The ruins of the chapel are still to be seen; though of the inner cave of which Pococke speaks, but did not visit, no trace was observed. The floor of the single chamber is littered with dirt and rubbish owing to its being occasionally inhabited during the winter by shepherds and their flocks. In spite of this a few scattered fragments of teeth and horns of ruminants could be seen adhering to the base of the walls of the cave.

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[1] See Spratt, op. cit., vol. ii, pp. 58–59.

[2] Op. cit., vol. ii, p. 195.

[3] "Descrip. Physique de l'Ile de Crete," p. 373; Paris, 1869.

A few days after arriving in Crete I rode out to the monastery of Haghios Joannes in the hills beyond the rich and important monastery of Haghia Triadha. Thence I walked down to the ruined and deserted monastery of Katholiko, or Gouvernente, near which is a cave which penetrates the side of the hill for a considerable distance. A visit was also paid to the well-known Cave of the Badger,[1] situated between the ruined monastery and that of Haghios Joannes. This has a tiny chapel and garden at its entrance, and consists of one large roomy chamber with a lofty roof. It contains a remarkable tank naturally enclosed by stalagmite which rises about eight or ten feet above the floor; for a great part of the year this is kept filled with delicious cold water which drips from a large stalactite hanging from the roof. No traces of an ossiferous deposit were found in either of these two caverns, and all enquiries for others in the district were met by the negative, this being all the more unfortunate as it caused me to cease investigations in the immediate vicinity.

It was not until the middle of July that I was shown and bought from a man near Khania a small elephant tooth about which he could, or would, give no information, except that it came from the Akrotiri. After several fruitless expeditions a villager interrogated at Khoridaki declared he knew of some petrified bones near the sea. Joining him a couple of days later (the 22nd) I was guided by a lonely hill path to Haghios Joannes, passing on the way the crumbling ruins of an ancient monastery. The ponies being left in the cave of Arkoudhes we walked down the hillside to Katholiko, which is situated at the head of a precipitous-sided and narrow, winding gorge. From here a scramble landed us in the dry stream-bed below, which was followed to the sea. Then turning to the left along the rocks at the foot of the cliffs a spot was soon reached where a few fragments of bone were found still adhering to the much weathered rock; these no doubt indicate the position of a former cave deposit, but otherwise are of little interest.

Returning to the mouth of the gorge, where my guide refreshed himself at a spring of mineral water much appreciated by the natives, I was about to retrace my steps, when a shepherd who had lately joined us volunteered to show me another deposit lying in the opposite direction. He led us over very rough ground towards Cape Maleka, just before reaching which we halted where the rocks and overlying débris slope steeply down to the sea from within a short distance of the top of the cliffs. This proved to be the site of the deposit of which I was in search, and which is only a few yards above the sea. No trace is left of the former cave walls, while the ossiferous deposit has been largely destroyed, though, judging from the fragmentary portions that remain, it must originally have been of considerable extent. It being then late in the afternoon a return was made the following day, when several portions of molars and a fragment of a tusk of a pigmy elephant were with difficulty detached from the hard substance in which they were embedded. Besides these some pieces of breccia containing the remains of small rodents were also procured. Unfortunately it was only possible to work here for a few hours, for, owing to the distance and rough track, it occupied four hours each way to and from Khania. The fact that this was the only deposit in which traces of a dwarf elephant were observed made it a matter of much regret that the investigations begun here could not be continued, but it was impossible to delay my departure from Crete beyond the 24th of the month.

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[1] Or 'bear,' as it is sometimes translated. In this case the word used is 'arkoudhes,' though the name usually employed in the island for badger is 'arkaloa.'

The first trip into the country from Khania took me to the monastery of Gonia, near Kolymbari, which was reached on March 20th after a ride of several hours, chiefly along the seashore. The following morning no difficulty was experienced in finding the cave (Plate IX) already described by Admiral Spratt,[1] who obtained from it a few remains which he mentions as having been identified by Dr. H. Falconer[2] as those of "a goat, a roebuck, or stag, and of a small *Myoxus*." For several days some work was carried on here, but without much success, for the ossiferous deposit, which was very hard, extended only a little way inside the cave, and specimens worth preserving were difficult to obtain. A number of other caves on this side of the peninsula, including the Kimido Spilia of the Admiralty Chart, were examined, but without result.

Later, when staying at the tiny village of Kamara Kumuli, I was taken to a small cave or hole in the cliffs below, and somewhat to the south-west of Ravduka. In spite of the stalagmitic flooring of what remained of this cave being entirely broken up, presumably by the action of the waves, some few good specimens were obtained from a crevice half-filled with earth and sand. A portion of the bone breccia could be seen to extend for a short distance below the present level of the sea. The remains noticed here included only those of the two species of ruminants already mentioned.

On a trip to Malathiros, which lies some little distance in the hills inland, no bone caves were heard of, but more success attended a return to the coast still further west. At the western base of the Grabusa Akrotiri lies the small promontory of Kutri, or Phalasarna, to give it its ancient name, the site of the western town of the early civilization of Crete.[3] At the northern edge of this cape, where the limestone cliffs are reduced to an insignificant height, a cave opening towards the sea was found to contain the remains of a large ossiferous deposit. That this must originally have been of considerable extent is shown by the fact that between the highest and lowest traces of bones is a distance of fifteen feet; these probably occurred in bands of about three feet in thickness and separated by layers of stalagmite. Two such bands were clearly traced at the inner end of the cave; in the upper remains of an ntelope were most plentiful, while in a lower one horns and teeth f a deer predominated.

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[1] Op. cit., vol. ii, pp. 194–5.

[2] I have been unable to find any account of these remains published by Dr. Falconer.

[3] Spratt, op. cit., vol. ii, chap. xix.

In the cliffs less than a hundred yards to the south-west is another ve which can only be reached from the sea. This is smaller and rrower than the one described above, and contains only a very gmentary remnant of an accumulation of mammalian remains. sides this some few specimens were brought in by one of my men, ho said he had procured them from a cave on the east coast of e Grabusa promontory and about two hours walk from Kalivjannee, t I was unable to go and verify this information. Previously, hen at the eastern base of this Akrotiri, a great number of fossilised mains of a large echinoderm were noticed in the low sea-cliffs at is spot.

Before leaving Mesoghia,[1] whence the Kutri cave was worked, visit was paid to Sphinari on the coast at some hours stance to the south. Its position is somewhat isolated, and it claimed by the inhabitants to be an outlying village of the nneakhoria. A walk of less than an hour along the cliffs on the uth side of the small bay brought us to the partially submerged mains of a cave deposit, now almost entirely destroyed. Of the ve itself this is the only trace to be seen; some teeth and bones of minants and part of the dentition of a rodent were obtained here.

No other deposits were found west of Khania, but before de-ribing those discovered in the east of the island a few remarks the former may not be out of place. Apart from the interest the mammalian remains contained in them the situation and ndition of these deposits suggest a number of problems as to the obable method of their origin, to which it seems difficult to supply y satisfactory explanation. The Kutri cave may be noticed with ore detail, presenting as it does phenomena somewhat similar to e smaller Kutri cave, that near Ravduka, and the deposit ose to Sphinari. The lowest trace of bones is only about 10 feet ove the sea, while the whole floor bears unmistakable traces of ving been largely broken up and to a great extent washed away. n the walls of the cave is a distinct sea-level mark now about) feet above the water. In confirmation of this it seems to have en satisfactorily proved by the observations of Admiral Spratt[2] at a local[3] "déplacement negatif" to the extent of 22 feet has ken place at this point of the coast, and that *within historical times*, aking it a matter of certainty that this has occurred since the cumulation of the ossiferous deposit.[4] A similar alteration of the coastline, though in a greater or less degree, is recorded by this author for nearly the whole of the west coast of Crete.

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[1] This is an isolated homestead which, although close to Kalivjannee, is called esoghia, no doubt after the villages of that name to which it probably belongs.

[2] Op. cit., vol. ii, chap. xix, pp. 195–6, etc. Suess also gives a list of records in is connection; see "La Face de la Terre," vol. ii, pp. 700–1 and 740.

[3] That this was only local is proved by the fact that in the east of the island contrary movement has occurred also within historic times. See Spratt, op. cit., l. ii, pp. 21–2, etc., and Suess, op. cit., vol. ii, pp. 700–1.

[4] Admiral Spratt even says in discussing the disappearance of the harbour at ripiti, on the south coast, which was described by the author of the "Stadiasmus," that is is "another proof of the great upheaval along the coast having taken place since late Roman period, the date of the 'Stadiasmus' being considered to be about at time" *(op. cit., vol. ii, p. 246)*.

It might be assumed that the ossiferous remains were introduced into the cave by the sea, but on the other hand several facts seem to suggest a different explanation. The appearance of the interior of the cave points conclusively to its having been invaded by the sea subsequently to the deposition of the mammalian remains as already mentioned above. The material in which these are embedded is exactly similar to that found in other caves differently situated, and does not contain sea shells, though a few occurred, together with a small quantity of sand, in a hole or crevice. Some of these were adhering to pieces of bone which were exposed at this spot, but none were found enclosed in the solid matrix in conjunction with the mammalian remains. A considerable quantity of coarse sand was also observed in a crevice containing a number of remains in the cave near Ravduka.

As an alternative the only manner in which it seems at all possible that these remains could have been deposited in the caves when under water would be through the agency of an underground river with its outlet below the surface of the sea. Accumulations might then have formed in a backwater or eddy, or even in the main stream when it had become sufficiently reduced to allow of this. The partial destruction of the deposits by sea action would take place when the sea and cave eventually occupied relative positions that would allow the surf to break in with some force. In Crete, as in other limestone countries, these subterranean streams are by no means uncommon;[1] as examples mention may be made of the swallow-holes, locally known as khonos or katavothron, which carry off the waters from a number of hill-encircled upland basins. Besides these are several streams with a large flow of water which abruptly rise out of the ground, as near Haghios Nikola, at Armyro west of Candia, and at Armyro on the coast at the south-west corner of Armyro Bay.

On the whole it seems easier to believe that these bone breccias were originally formed on the floors of land caves subsequently submerged beneath the sea, from which they have again been gradually elevated to the extent already noted.

To account for the disappearance of the walls and roof of some of these caves, such as at the deposit near Cape Maleka and several others in the east of the island which have not been submerged, is not difficult. For even where the action of the sea has played no part, or only to the extent of surf breaking in during storms, the effects of weathering on these practically barren limestone rocks is very rapid and severe. As a factor of possible importance in the destruction of the caves, it may be remembered that Crete lies within the zone where earthquakes are of by no means infrequent occurrence; a particularly severe one doing much damage to many of the towns occurred as late as 1856.

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[1] An interesting paper dealing with this subject is "Submarine Gullies, River Outlets, and Fresh-water Escapes beneath the Sea-level," by H. Benest, Assoc. M. Inst. C. E.: Geog. Journal, October, 1899, vol. xiv, pp. 394–413.

EASTERN CRETE.

the beginning of May, shortly after returning to Khania from
ond trip in the west, a start was made for the east, where
ained until shortly before leaving the island in the latter end
ly. Candia was reached, after a somewhat wandering course,
ling Lake Kurnas, Myrthio (from whence one of the small
f fossil wood mentioned by Raulin[1] was visited), Kria Vrisis,
tos, and Haghia Deka, near which is the enormous underground
y known as the Labyrinth.

ng the coastline east of Candia no cave deposit was found
Melato, in the eparkhia of Mirabello, was reached. Here one
iscovered on the bare hillside to the north-west of the village,
etween it and the sea. No part of the former cave was to
en except a few fragmentary portions of the stalagmitic
g showing above the ground, and containing remains of a pigmy
potamus.

the east of this my wanderings were continued through the
plain of Mirabello, and on by a road never very far from
ast to Sitaea. Thence to the monastery of Toplou, Eremopoli,
its ancient ruins, and Palaikastro, the site of important archæo-
l excavations made under the auspices of the British School
hens. A return was made across the limestone plateau in
Khandra is situated, by Daphnaes and Rhukaka, down the
to Kavusi, where the former route was joined.

e only cave deposits found in this part of the island were
ed in the rugged limestone cliffs bordering the southern end
Bay of Kharoumes, not many miles south of Palaikastro. At
oot of these cliffs and only from a few feet to a few yards
the sea were discovered one small bone cave and, on either
portions of the stalagmitic flooring of two others; all being
ed close together and extending for a distance of about
ndred and fifty yards. The most northerly of these deposits,
is at a greater height than, and at a little distance from, the
contained only bones and teeth of the small hippopotamus
also occurs at Melato. The remains in the cave and in the
deposit[2] proved to be those of ruminants similar to those
in the caves of the west of the island.[3]

ne little distance further along the coast in a south-easterly
ion is another cave, in which the floor is entirely broken up
eaped with huge boulders; at its inner end, however, a few
and a piece of a deer's horn were observed. These were
dded in the roof, which at this spot is partly composed of red
The position of these remains seems to be a strong argument
our of the idea that, at all events in this instance, they must

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p. cit., vol. i, p. 181, and Spratt, op. cit., vol. ii, pp. 270-1.

few land-shells were obtained here, and have been identified by the Rev. R.
ton Bullen as *Helix pellita*, Fer.

few fragmentary remains of a large proboscidian were found in the rocks
o this cave. They have not yet been examined, but will probably prove to
arlier age than Pleistocene.

have been introduced through the agency of water. The same was probably also the case in the other cave close by, in which it can be seen that, previous to the stalagmitic flooring having been disturbed, part of the bone breccia had reached to within about a foot of the roof, and this in the portion of the cave where the present entrance is situated. A curious point in connection with, though perhaps hardly in support of, this theory is that the different species were not found indiscriminately mixed together in any one deposit. The remains of the antelope and deer seem to be invariably associated, though the proportions in which they occur may vary in the different layers of the floor, as in the Kutri cave (p. 196). Bones and teeth of small rodents were, in one or two cases, found in the same deposit as the above; similarly they occurred in a fragmentary portion of the upper layer of the breccia near Cape Maleka, which besides these only contained remains of a pigmy elephant. Further, no other species was observed in either of the two cave deposits in which portions of a dwarf species of hippopotamus were found, although one of these, as already mentioned, was situated only a few yards from a cave containing remains of ruminants.

As long ago as about the year 1842[1] some remains of a small hippopotamus were obtained at Candia by Captain Graves, R.N., though it was not known where they came from. Somewhat later further specimens were procured at Kritsa, a large village on the eastern base of the Lassethe Mountains, by M. Raulin,[2] who was told that they had been found in the upland basin of Katharo. This spot he visited, and subsequently described, but without finding any specimens in the deposits in which they were said to occur. Owing to this information Kritsa was visited at the earliest opportunity, and here a small number of isolated hippopotamus teeth were brought in by the villagers, and at length an old man appeared who professed to know the locality from which they came. The following day he took us to the upland basin of Katharo, which is about three hours from Kritsa and nearly 4,000 feet above the sea. Although already past the middle of May, at this height it was bitterly cold, a keen wind bringing with it a damp and all-enveloping fog. This spot is not permanently inhabited, only a few shepherds staying here with their flocks during the summer months, when they and their beasts obtain shelter in rudely built and indescribably filthy hovels; the only other buildings being one or two small dedicatory chapels. A few crops of corn and vetches struggle for existence, while a number of fruit-trees grow in shelter of the northern hills. This mountain valley runs almost due east and west, and is about two miles long and from half to three-quarters of a mile wide. Completely encircled by hills, its surface presents an undulating appearance, particularly at its eastern extremity, and it is intersected by a number of streams all flowing westward, in accordance with the general inclination of the valley. These have excavated their courses in places to a depth of eight or ten feet, showing that the ground to this extent consists of reddish yellow and grey clays topped by a layer of darker soil varying in thickness from a couple of inches to one and a half or two feet. At the western extremity of Katharo, where the hills are lowest, the streams have broken through the rocky barrier, cutting a deep and narrow gorge by which the accumulated waters find a way to the more extensive upland basin of Lassethe, which lies nearly a thousand feet below.

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[1] Spratt, op. cit., vol. ii, p. 386.
[2] Ibid., pp. 386–7.

My guide first took me to the top of a rounded hillock in the eastern half of the valley, where a few fragmentary remains were found lying on the surface, where some débris evidently of volcanic origin, such as lava, etc., was also observed. During the next few days trial trenches were dug in a number of places in this vicinity, teeth and bones of a pigmy hippopotamus being found in varying quantities and at different depths. At the spot shown in the photograph (Plate X) the remains occurred somewhat sparingly in a band of bluish grey clay about one and a half to two feet thick. In a channel cut by a stream through yellowish clay others were found in great numbers at a depth of six to eight feet below the surface. Here the infiltration of water made them very rotten and difficult to extricate intact; however, eventually a number of teeth and jaws and a large series of perfect limb bones were obtained.

The presence of these hippopotamus remains shows that the deposit in which they occur is almost certainly of fresh-water origin, and this is easy to believe when it is remembered that before a channel was worn through the barrier of surrounding hills there was probably no outlet for the accumulated waters, which in that case would transform the valley into a lake or swamp, according to the season of the year. A view of the neighbouring enclosed plain of Lassethe encourages this idea, for here the only egress for the streams is by means of a swallow-hole, or khonos; should anything cause this to become blocked the drainage of both Katharo and Lassethe would be forced to remain in the latter, soon forming it into a marsh and possibly a lake after the melting of the snow off the surrounding mountains. Admiral Spratt mentions[1] that in spite of a swallow-hole in the upland basin of Omalo, in the Aspro Vouno, the centre of it is converted into a lake for some months during the winter.

Considering the ordinary habitat of the hippopotamus, it is curious to find numerous remains of a small species at the unusual height of nearly 4,000 feet above sea-level, and that amongst rugged and barren mountains. The above-mentioned author considered[2] that their occurrence in this situation "involves the necessity of conceiving great physical changes in the relative levels of sea and land since they existed in Crete." His suggestion of a depression in this part of the island to the extent of some 3,500 feet would seem

[1] Op. cit., vol. ii, p. 176.
[2] Ibid., p. 387.

to be disproved by the discovery of similar, and presumably contemporary, remains nearly 4,000 feet below Katharo. May it not be that this upland basin, then a lake or marsh, became a last stronghold of a dying race of hippopotamus? This does not seem so improbable if we imagine a slightly warmer climate to have been then prevailing, and with it the consequent existence of a vastly greater amount of vegetation.

CONCLUSION.—It will be seen from the above that during my stay in Crete thirteen deposits containing remains of Pleistocene mammals were found, though only four were worked to any extent. These are all situated in the northern half of the island, for it was found impossible in this time to explore more than a comparatively small area, and that imperfectly; the southern coastline was practically unvisited. This was partly due to the distances to be traversed and the slow rate of progress over rough country; the total disappearance in many cases of all traces of the caves save a portion of the stalagmitic flooring greatly added to the difficulties of their discovery.

The following is a list of Pleistocene ossiferous deposits found:—

1. Cave deposit near Sphinari, West Crete. (p. 197.)
2. Cave, Cape Kutri, West Crete. (p. 196.)
3. Cave, Cape Kutri, West Crete. (p. 197.)
4. Haghios Basilis (cave), near Ravduka, West Crete. (p. 196.)
5. Tripiti cave, near Gonia Monastery, West Crete. (p. 194.)
6. Cave between Khania and Suda, West Crete. (p. 194.)
7. Cave at Haghios Georgios, Khania Akrotiri, West Crete. (p. 194.)
8. Cave deposit below Katholiko Monastery, West Crete. (p. 195.)
9. Cave deposit near Cape Maleka, West Crete. (p. 195.)
10. Cave deposit near Melato, Mirabello, East Crete. (p. 199.)
11. Cave deposit (3 ?), Kharoumes Bay, Sitaea, East Crete. (p. 199.)
12. Cave, Kharoumes Bay, Sitaea, East Crete. (p. 199.)
13. Fresh-water deposit, Katharo, Lassethe Mountains, East Crete. (p. 201.)

The mammalian remains found in the above have not yet been specifically determined, but are known to include the following: antelope, deer, elephant, hippopotamus, shrew (*Crocidura*), and at least two small species of rodents. Of these the elephant and hippopotamus represent dwarfed races, whilst the antelope will probably be found to belong to a hitherto undescribed form. It is hoped that it will be possible before very long to publish a detailed account of these remains. I take this opportunity to express my sincere appreciation of all the help and encouragement I received from many kind friends both at home and in Crete.

EXPLANATION OF PLATES.

PLATE IX.—Tripiti Cave, near Gonia Monastery, West Crete.[1]

PLATE X.—Men at work in the upland basin of Katharo, Lassethe Mountains, East Crete.

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[1] Ossiferous remains occur in the cliff-face immediately below the mouth of this cave, as well as inside (see Spratt, op. cit., vol. ii, p. 195).

Dec. V. Vol. II. Pl. X.

—NOTES ON BRITISH DINOSAURS. PART I: *HYPSILOPHODON*.

By DR. FRANCIS BARON NOPCSA.

(WITH A PAGE-ILLUSTRATION.)

RING a recent stay in London the kindness of Dr. A. S. Woodward enabled me to study some of the splendid Dinosaurian ns in the British Museum.

ving principally occupied myself till now with Ornithopodous aurs, first of all *Hypsilophodon* attracted my attention, and cpectation that this type would prove to be the clue for the standing of all the other Orthopoda has been perfectly fulfilled. *psilophodon* was described and figured at various times by , Huxley, and Hulke; a restoration of this animal was given arsh in the GEOLOGICAL MAGAZINE for 1896 (p. 6, Fig. 2), he complete bibliographical list concerning this Dinosaur is iled in my paper "Synopsis und Abstammung der Dinosaurier" *tani Közlöny*, 1901, Budapest).

consequence of our more recent knowledge of Dinosaurs in al I managed to detect some new points of remarkable interest.

ndible. What Hulke, in describing the *Hypsilophodon* skull, 10, supposed to be the parietal, frontal, and post-frontal bones . Trans., 1882, pl. lxxi, fig. 1, *pa.*, *fr.*, *ps.f.*), turned out to be uter view of a complete right mandibular ramus, so that the al changes into an articular, the frontal becomes the dentary, he post-frontal the coronoid bone. This piece (p. 207, Fig. 4) is, t, the finest mandibulum of *Hypsilophodon* I have seen in the collection, and as such worthy to be refigured.

e general outline of the mandibulum, with its strongly abated post-coronoidal part and its blunt processus coronoideum, ds one somewhat of the under jaw of *Placodus gigas*, though fers of course in nearly every detail, being built up after the *odon* type. The comparatively very slight elevation of the coronoideum, a feature in which *Hypsilophodon* differs from *odon* and the Hadrosauridæ, is to be met with in the Upper ceous *Mochlodon*, while the abbreviation of the post-coronoidal of the lower jaw is a character which among all Dinosaurs is known in the *Iguanodon* type.

called sclerotic plates. After fixing former differences of intertion Hulke's so-called sclerotic plates were closely examined, proved to be nothing else but the teeth belonging to the same mandible, showing each a nicely polished masticating e; the pointed projection on each of these so-called sclerotic being simply due to the median ridge projecting on the inner elled surface of each tooth (compare my similar figure of the cating surface in *Mochlodon* teeth figured in my paper on *lodon* in the Denkschr. d. k. Akad. Wiss., Vienna, 1901, pl. ii, 1).

si-occipital bone. Another point of great interest not yet duly d in the skull of *Hypsilophodon* is the shape of the *bird-like* occipital bone (Fig. 1, *bo.*). It is utterly unlike the same bone in *Camptosaurus*, *Mochlodon*, *Iguanodon*, or *Telmatosaurus*, but rather reminding one of the *Compsognathus* or *Thecodontosaurus* type; and the *downward* direction of the foramina by which the cranial nerves pass out from the brain-cavity along the basal and lateral elements of the skull is an especially bird-like feature. Describing the basi-occipital and basi-sphenoidal elements in *Mochlodon*, I stated these elements in *Gresslyosaurus* are in the same relation to the same parts in *Zanclodon* as are those of *Mochlodon* to *Telmatosaurus*, and thus I could distinguish a *Mochlodon*-*Gresslyosaurus* or elongated and a *Telmatosaurus*-*Zanclodon* or abbreviated type. To this now a third type, the *Hypsilophodon*-*Thecodontosaurus* or bird-like type has to be added. The great phylogenetic and physiologic value of this fact, throwing much light on the relationship of Dinosaurs and birds and also on Dinosaur evolution itself, will be more fully explained on some other occasion.

Supra-occipital bone (p. 207, Fig. 2). As it has some years ago been doubted by Professor Koken that in Ornithopodidæ the supra-occipital enters into the foramen magnum (Neues Jahrb. f. Min. Geol. u. Pal., 1901, vol. i), it seemed desirable to settle also this question, and therefore a drawing of this part of another *Hypsilophodon* skull is also given. It will be seen at once that the supra-occipital contributes largely to the boundary of the wide foramen magnum, and that it rises very much in the same way as in *Hatteria* or *Compsognathus*, forming at the same time a sharp median posterior crest. The differences from the *Acanthopholis* or even the *Iguanodon* type are easily noticed. The processus parotici are not raised as in *Telmatosaurus*, but at the same level as the foramen magnum, and, showing at once where the missing squamosals are to be sought for, this indicates that the quadrate bone was *comparatively* short, that the superior temporal openings were visible from the side, and proves the presence of large hypoparotic fossæ.

Predentary. Although this bone is of quite exceptional interest, and was already described by Hulke in his monograph on *Hypsilophodon*, yet it never has been figured. *Hypsilophodon* is, as far as we know, the single Dinosaur in which a tooth bearing a præmaxillary comes to bear down on a predentary bone, and this is the reason why in p. 207, Fig. 3, an enlarged drawing of this element is given.

Dollo remarked some years ago that a toothed præmaxillary might well correspond to a tooth-bearing predentary, and I perfectly agree with the famous Belgian professor that this is exactly the thing one ought to expect if the predentary of the Orthopoda were an entodermal ossification and homologous with the same bone in *Aspidorhynchus*, *Amphignathodon*, or in human anatomy.

Working along quite other lines of research than Professor Dollo, I, however, recently came to the result that the predentary of Orthopoda cannot have been derived from a cartilaginous source, but must simply be regarded as a dermal ossification (Denksch. Akad., Vienna, 1904). The paradoxical fact that in *Hypsilophodon* an edentulous predentary meets a toothed præmaxillary is, as far as

I am aware, the best evidence that can be brought forward in favour of the newer interpretation. A comparison of this predentary bone with the one of *Mochlodon* and other Predentata, as figured in my third paper on Transylvanian Dinosaurs, is equally interesting, and the gradual prolongation of this bone along the line *Camptosaurus*, *Telmatosaurus*, and *Trachodon* may perhaps be termed as a sort of dolichocephaly due to the cursorial habits of these Phytophagous reptiles.

Præmaxillary. No doubt has hitherto been expressed regarding the statement that the front part of the jaw in *Iguanodon* was covered with a horny beak, and therefore an examination of the tooth-bearing præmaxillary in *Hypsilophodon* was also one of the tasks that had to be accomplished.

On the top of the well-preserved præmaxillary of one skull (Hulke, 1882, pl. lxxi, fig. 1), soon a small but pronounced rugosity was detected, and it was at once highly suggestive that this might be the place whence that dermal ossification originated which, spreading by and by over the whole præmaxillary, gradually formed the beak of the Orthopodous Dinosaurs and suppressed the function of some teeth. That this beak did, however, not yet act effectively in *Hypsilophodon* is, I think, proved by the presence of the well-developed præmaxillary teeth. As placed on the front part of the præmaxillary the rugosity mentioned is at the same time exactly on the place where in some reptiles and birds the *Eischwiele* of the German author appears, and the idea that this is more then a mere coincidence is perhaps not to be disregarded altogether.

Dermal ossifications (armour). Contrary to what we know of *Iguanodon*, *Hypsilophodon* was surely clad with a thin but a well-developed dermal armour, consisting of comparatively large yet thin and flat, feebly punctured bony plates. I managed, at least, to detect in more than one specimen some plates always showing the same sort of feebly grooved sculpture, and never referable to any part of the endoskeleton itself. A good sketch of such plates is given in one of Hulke's figures, and in p. 207, Fig. 4, of this paper the grooved markings also come out pretty well. This dermal armour is, again, a character in which *Hypsilophodon* approaches more closely the armour-clad Stegosaurs and Ceratopsia than any other Ornithopodous Dinosaurs.

Ossified dorsocaudal tendons. The first figure of ossified dorsocaudal tendons in a Dinosaur dates back to the year 1849, and is a figure representing parts of the tail of *Hylæosaurus*. Later on the same elements were mentioned by the Rev. W. Fox in *Polacanthus* (*Illustrated London News*, 1865). Again, in 1882 a figure and a short remark on these curious objects was given by Hulke in his *Hypsilophodon* paper, and in 1887 they were refigured very clearly in his paper on *Polacanthus*. In the same year (1887) came finally L. Dollo's paper mentioning them in *Iguanodon* and dealing with their physiological value. Thus ossified dorsal tendons are present in all the British Prædentate reptiles, with the sole exception of the

Liassic *Scelidosaurus*. It is to be remarked that (1) the rhomboidal arrangement of these tendons described in *Iguanodon* seems to be absent in *Hypsilophodon* as well as in the North American *Claosaurus*; (2) that in *Iguanodon* these ossifications are *absent* under the diapophysis, while in *Hypsilophodon* they are present also on this place, and form thus on each side of the tail two bundles which run along the neurapophyses and the chevron bones. Besides this the ossified tendons attain in *Iguanodon* their maximum of development in the lumbar region, while in *Hypsilophodon* their number augments the nearer we approach the end of the tail, so that this region is *entirely* ensheathed. The physiological value of such a rigid organ, already unexplainable in *Iguanodon*, becomes in consequence entirely a puzzle.

Fourth trochanter. Though the fourth trochanter of *Hypsilophodon* was already well figured and described by Hulke, I still feel induced to mention also this part, since Hulke in the *Neues Jahrbuch für Mineralogie* expressed some time ago his doubts about the correctness of my assertion that the 'trochanter pendant' represents a more primitive stage in evolution than the 'trochanter en crête.' Now I find that the trochanter pendant of *Hypsilophodon* just seems to prove the correctness of my original view. In *Hypsilophodon* the fourth trochanter is comparatively much broader than in *Camptosaurus*, where it also shows the pendant type, and in the Wealden *Iguanodon*, again, it is much more developed than in *Trachodon*, of the Belly River and Laramie Series. Comparing this fact with the development of the teeth in these animals, we find that the more complex development of the teeth runs parallel with the diminution of the fourth trochanter. At the same time the diminution of the fourth trochanter is also accompanied by the development of what I formerly called the processus pectinealis of the Orthopode pelvis (*Földtani Közlöny*, 1899, Budapest), but for which I now adopt the more appropriate name of processus pseudopectinealis. As it is now possible to prove that the development of the processus pseudopectinealis as well as the more complex structure of the teeth are due to *progressive* and not to *retrogressive* evolution, and since it is impossible to suppose that some sort of quite especial *chevauchement de specialisation* is disturbing the *whole* line from *Hypsilophodon* to *Trachodon*, it is equally impossible to sustain the view that the smaller fourth trochanter represents the primary state, and on account of this I think the fourth trochanter in *Hypsilophodon* may be brought forward as one of the principal arguments for sustaining my hypothesis concerning the fourth trochanter.[1]

Conclusion. The following characters in *Hypsilophodon* can be considered as new or definitely settled:—No sclerotic ring. Coronoidal process blunt and low. The dermal predentary certainly edentulous. Præmaxillary with rugosity on the front end. Condylus basi-occipital, and the whole base of the skull very bird-like, reminding us more of some Theropoda than of the true Ornithopodidæ.

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[1] Other arguments I intend discussing upon another occasion.

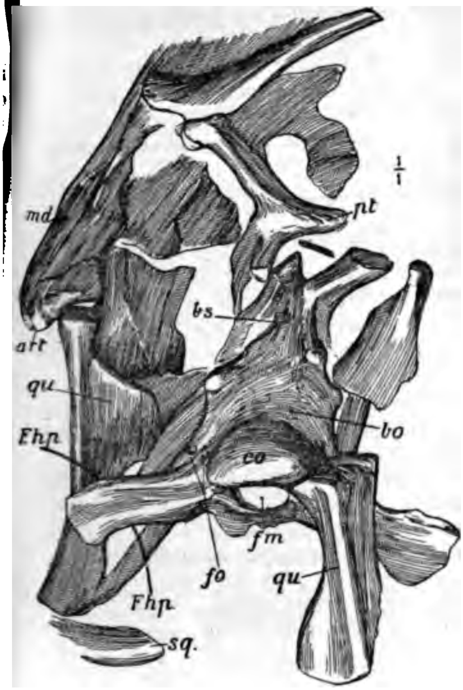

Fig 1

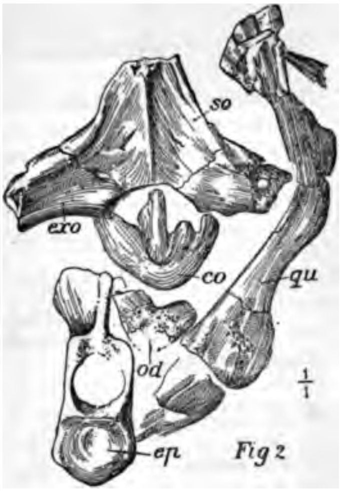

Fig 2

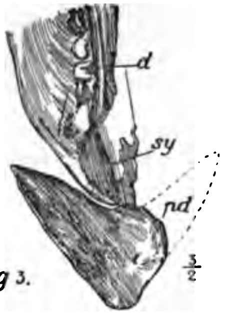

Fig 3.

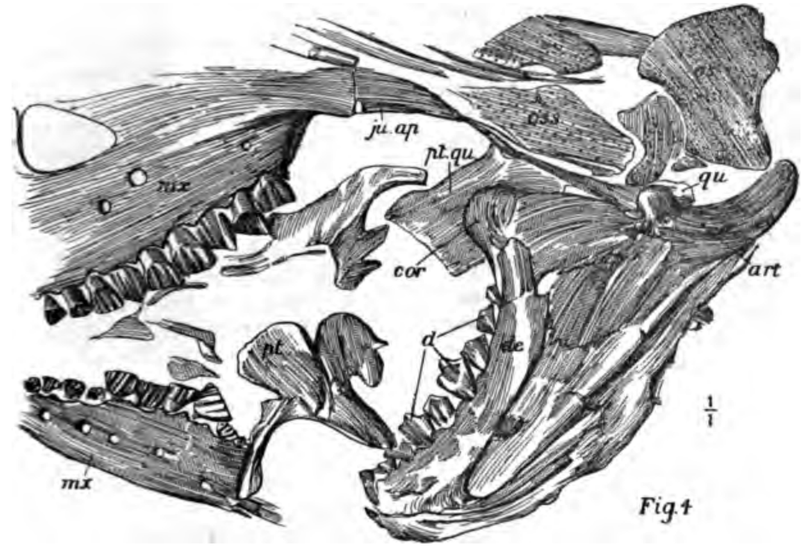

Fig.4

British Dinosaurs : I. *Hypsilophodon.*

Supra-occipital entering largely into the foramen magnum. Processus parotici not raised. Large fossa hypoparotica present. Dermal armour present and well developed. Ossified dorsocaudal tendons run along neurapophysis and chevron bones, and augmenting in number towards the end of the tail.

EXPLANATION OF PAGE-ILLUSTRATION (p. 207).

FIG. 1.—Base of skull of *Hypsilophodon* ($\frac{1}{1}$).
,, 2.—Back of skull of *Hypsilophodon* ($\frac{1}{1}$).
,, 3.—Predentary of *Hypsilophodon* ($\frac{2}{1}$).
,, 4.—Mandible of *Hypsilophodon* ($\frac{1}{1}$).

art.	articulare.	*md.*	mandibulum.
bs.	basi-sphenoid.	*mx.*	maxillare.
co.	condylus.	*od.*	processus odontoideus.
cor.	coronoideum.	*oss.*	dermal ossifications.
d.	dentes.	*pd.*	predentary.
ds.	dentale.	*p.p.*	processus paroticus.
ep.	axis (epistropheus).	*pt.*	pterygoid.
exo.	exoccipitale.	*pt.qu.*	processus pterygoideus quadrate.
f.hp.	fossa hypoparotica.	*qu.*	quadratum.
f.m.	foramen magnum.	*so.*	supra-occipitale.
fo.	foramina of cranial nerves.	*sq.*	squamosum.
ju.ap.	jugal apophysis of maxillary.	*sy.*	symphysis mandibuli.

III.—ON A LEPIDODENDROID STEM FROM THE COAL-MEASURES.

By BERNARD SMITH, B.A., Sidney Sussex College, Cambridge.

AMONG the numerous Lepidodendroid remains in the Geological Department of the British Museum (Nat. Hist.), there is one which presents several characters of unusual interest. It is a cast obtained from the Middle Coal-measures of South Staffordshire, near Dudley, and belongs to the Johnson Collection.[1]

A portion of the specimen is figured on p. 209. It will be noticed that the mammillated leaf-cushions are distant from one another, and are separated by broad bands of striated bark. This is an unusual feature in the case of British Lepidodendra. The preservation is fairly good, except in the details of the leaf-scar. In the specimen thirteen leaf-cushions are represented, forming portions of five spiral series. The cushions are rhomboidal in outline, and at first sight do not appear to be very sharply marked off from the bark. On closer inspection, however, they are seen to be moderately well defined, although the lateral angles are flattened and obscured by the encroachment of the bark. They measure from 1·8 to 2 cm. in length, and from ·6 to ·7 cm. at their greatest width. The upper and lower extremities lie in one plane, which is the median plane of the cushion, and are inclined neither to the right nor to the left (cf. *Lepidodendron serpentigerum*). The cushions stand out in high relief, and depart somewhat from the form of a low truncated pyramid so commonly seen amongst Lepidodendra. However, this is in no wise remarkable, for examples of Lepidodendra having raised cushions are not rare, in cases where the stems have to some extent escaped rushing. In profile each one may be compared with a wall-bracket, n which the shelf is represented by the knob-like projection situated bove the leaf-scar. The upper and lower divisions of the field are rnamented by a central keel.

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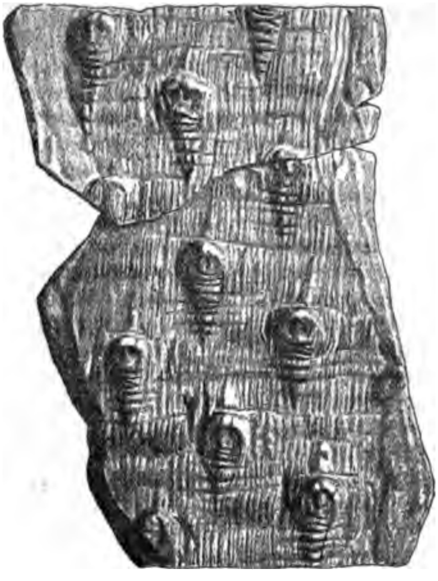
[1] Registered number V. 1233.

The leaf-scar is placed, not at the apex of the cushion, as in iany species of Lepidodendra, but in a subordinate position, below ie apex. The details of the scar are somewhat indistinct. The pper extremity appears to be slightly notched, the lateral angles are oscure owing to the above-mentioned overlap of the bark, and the ase is truncated. A print, presumably the leaf-trace scar, can be istinguished, but the preservation is not sufficiently good to enable ne to recognise the parichnos. On that portion of the field lying elow the leaf-scar a few transverse wrinkles occur. They are sually somewhat oblique, tending to coalesce, and might, as in ie case of *Lepidodendron Wortheni*, be regarded as a specific haracter. In addition there are a number of other folds, clearly een in the figure, which run right across the cushion and are ontinued in the bark on either side. These are almost certainly ue to shrinkage, and are not the result of natural growth.



Lepidodendron sp., from the Middle Coal-measures near Dudley. Nat. size.

The most interesting feature presented by this cast is the fact iat the leaf-cushions are widely separated. Each cushion is placed t a distance of 1·6 to 1·7 cm. from its neighbour in the same spiral, nd 2·3 cm. from its nearest neighbour in the spiral above or below. hese measurements are taken from centre to centre of the leaf-scars.

The leaf-cushions are thus entirely separate from one another. Two examples of ***Lepidodendron serpentigerum***,[1] König, derived from Newcastle and now preserved in the British Museum, have been found to measure 1·1 cm. and 1·6 cm. respectively from scar to scar; but the cushions occupy a much greater relative proportion of the external surface of the stem than they do in the present case, whilst they are connected with one another by tail-like prolongations running from the lower extremity of the leaf-cushion above to the upper extremity of that beneath. It appears that it is not uncommon in some species of Lepidodendra to find the cushions separated by a certain amount of bark, as in the instance above cited, where the two occupy almost equal areas. But it certainly is unusual that such a relatively large proportion of the whole area of the stem or branch—roughly three-fourths of it—should consist of bark. To quote Mr. Kidston[2]: "The leaf-cushions are arranged in steep spirals and are contiguous, as in *Lepidodendron ophiurus*, Brongt., or more or less distant, as in *Lepidodendron rimosum*, Sternb., or *Lepidodendron serpentigerum*, König, where the cushions end in tail-like prolongations, by which the various members of the same spiral series are connected to each other. In some species, however, the leaf-scars are contiguous or more or less distant, according to the growth or age of the individual. This is seen in *Lepidodendron aculeatum*, Sternb. In some species, as in *Lepidodendron serpentigerum*, König, the leaf-cushions are always distant, so far as at present known, and the interfoliar space is ornamented with fine irregular wavy lines, and a somewhat similar form of ornamentation of the bark appears to be a constant character in all species where the leaf-cushions are distant."

The bark is wrinkled longitudinally, the fine corrugations anastomosing at small angles. The striæ do not sweep round the cushions, as in *L. serpentigerum*, *L. veltheimianum*, *L. corrugatum*, and some other species; but terminate sharply against them. At the widest part of the cushion they sweep over its angles, maintaining, however, their longitudinal direction. We might compare these striæ with those of *L. distans*,[3] Lesqr., which also end abruptly at the cushions, but do not encroach upon them.

The general appearance, the shape of the specimen, and the fact that it has, in all probability, not been considerably crushed, all seem to favour the idea that it is a part of an old branch or stem. Moreover, in some Lepidodendra we find that as the stem advances towards maturity, the leaf-cushions often tend to become more elongated, especially in cases where the cushions of the young branches are as broad, or broader than long. For example, those of *L. dichotomum*, Zeiller, are shorter than broad; those of *L. obovatum*, Sternb., as long as broad. So we might argue that the length of the cushions in the specimen described here is indicative of advanced age, though this evidence, being merely negative, is not of any great value. Although there is no means of ascertaining, in the absence of other specimens, whether this species had approximating or contiguous leaf-cushions at a younger stage in its development, the fact still remains that the relative distances between the leaf-cushions, as compared with those of other Lepidodendra, even in advanced age, is more or less exceptional. In this respect no British species with which I am acquainted approximates to it. *Lepidodendron serpentigerum*, König, and *L. distans*, Lesqr., offer the closest resemblances; but in view of the indifferent preservation of the leaf-scar, I consider that it would be unwise to attempt either to classify it with any existing British species or to give it a specific name of its own.

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[1] Registered number 38,089.

[2] Kidston, "Carboniferous Lycopods and Sphenophylls": Trans. Nat. Hist. Soc. Glasgow, N.S., vol. vi, p. 46 (1899-1900), 1901.

[3] Regarded as identical with *L. serpentigerum*, Kön., by Kidston: Cat. Palæoz. *Plants* Brit. Mus., p. 157, 1886.

My thanks are due to Miss Woodward for the figure with which this article is illustrated, and to Mr. Newell Arber, both for introducing the specimen to my notice and for the interest that he has taken in this work.

IV.—ON A COLLECTION OF TRILOBITES FROM THE UPPER CAMBRIAN OF SHANTUNG, NORTH CHINA.

By HENRY WOODWARD, LL.D., F.R.S., F.G.S.

THROUGH the kindness of my friend Mr. E. T. Newton, F.R.S., of the Geological Survey Museum, Jermyn Street, I was placed, in October, 1902, in correspondence with the Rev. Samuel Couling, M.A., of the English Baptist Mission, Ching-chou-fu, Kiao-chow, North China, who obligingly transmitted to me several fossils which he had obtained from "West Shantung, and south of Tsing-tshou-fu, 36° 40′ N. lat. and 118° 40′ E. long." He referred me to Richthofen's Atlas, on which the hills where the fossils had been obtained are marked "Mittel und Ober Sinisch"—between Cambrian and Silurian in age.

The collection, which was added to by Mr. Couling a year later, contains several portions of Trilobites and a slab entirely covered with detached Trilobitic remains, reminding one of similar beautiful slabs (frequently to be seen in museums) from the Wenlock shale of the Wren's Nest, Dudley, England. In addition to the Trilobites, there were several Cephalopods and photographs of others, from the same province. Some of these straight-shelled Nautiloids, collected by Mr. Couling, have already been figured and described in this Magazine by Mr. G. C. Crick in November, 1903,[1] and a further paper has been promised by the same author. An account of the Trilobites would have followed some time since (indeed, figures had been already prepared), but having learnt that a similar collection from Shantung had already been sent to Berlin, and published by Herr H. Monke (Berlin), in 1903, I delayed doing so until I was in possession of a copy of that paper, of which I here subjoin an abstract.

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[1] See GEOL. MAG., Dec. IV, Vol. X (1903), pp. 481–486, Pl. XXII, etc.

To this I propose presently to add a note on the Trilobites and upon some additional specimens collected by the Rev. S. Couling, and to give a photographic reproduction of a part of the slab sent to me by him. All the specimens (including the slab) have, by his desire, been presented to the Geological Department of the British Museum (Natural History), Cromwell Road, S.W.

The following is an abstract of Herr H. Monke's paper, entitled:—"Contributions to the Geology of Shantung.—I. Upper Cambrian Trilobites from Yen-tsy-yai." [1]

The 'Sinische Formationsreihe' (Sinic formation), as it is called by Von Richthofen,[2] is a series of strata of from 4000–7000 metres in thickness, composed of conglomerates, sandstones, clay-slates, and limestones, which in Northern China covers the steeply inclined folds of the Archæan formation, and which in turn is covered almost conformably by the Carboniferous formation. The lowest members of this series consist of conglomerates and coarse sandstones, the products of disintegration by the sea, transgressing from S.E. to N.W. These are succeeded in ascending order by an alternating succession of siliceous limestones with arenaceous or argillaceous strata, and finally by pure limestones, partly of a peculiar, globulitic form. Accordingly, we may distinguish between a Lower Sinic arenaceous, a Middle Sinic arenaceo-calcareous, and an Upper Sinic calcareous division. Von Richthofen regards this series of strata as belonging on the whole to the Cambrian, but he is of opinion that "the formation in China extends much lower down and therefore embraces a much longer period, whilst upwards it may extend into the Lower Silurian without any appreciable break." [3]

[p. 104] This view rests on the results at which Dames and Kayser[4] had arrived from the study of numerous Trilobites and some Brachiopoda collected by Von Richthofen in the Upper Sinic Limestones near Sai-ma-ki, Ta-ling, and Wu-lo-pu, in Liautung.[5] According to Dames, who worked out the Trilobites, the fauna of Sai-ma-ki consists chiefly of two species of the genus *Conocephalus*, whereas the genera *Anomocare* (3 species), *Liostracus* (1 sp.), and *Agnostus* (1 sp.) occur only quite isolated. Near Ta-ling the limestones, which here are partly globulitic, contain, with the exception of *Agnostus*, the same genera (4 *Conocephalus*, 2 *Anomocare*, 2 *Liostracus*), the species being, however, different, with the exception of *Conocephalus frequens*,[6] which is the most common of all in both localities. Dames therefore considers the two faunas as essentially contemporaneous and nearly corresponding to the horizon of the Scandinavian Andrarum Limestone, and to the lowest division of the Potsdam Sandstone in America.

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[1] Extracted from the Jahrbuch d. kön. Preuss. Geolog. Landesanstalt und Bergakademie for the year 1902, vol. xxiii, fasc. 1, pp. 103–151, Tafel iii–ix (Berlin, 1903).

[2] "China," vol. ii (1882). See especially pp. 73, 79, 1C7, 223, 316.

[3] Op. cit., p. 108.

[4] "China," vol. iv (1883).

[5] These three localities are situated near the Corean frontier: Ta-ling about 51 kilometres north of Sai-ma-ki, and Wu-lo-pu about 62 kilom. north-west of Sai-ma-ki, or 28 kilom. west of Ta-ling.

[6] The assumption on p. 17 (op. cit.) that *Anomocare planum* occurs likewise near Sai-ma-ki is, according to pp. 28 and 30, apparently a mistake.

The fauna of Wu-lo-pu, on the other hand, is characterized by the new genus *Dorypyge*, in addition to which there are only found the genera *Liostracus* (1 sp.) and *Anomocare* (1 sp.); no other species, however, is in common with the before-mentioned faunas.[1] With the genus *Dorypyge* Dames associates *Dicellocephalus gothicus* and *D. quadriceps*, from the 'Quebec group' of Utah, and concludes therefrom that the strata of Wu-lo-pu are of Lower Silurian age.

At a later date Gottsche[2] found Sinic strata, extending over 25 kilom., in Corea, near the frontier towards Liautung; above [p. 105] massive siliceous sandstones there follow fossiliferous marly slates and bituminous limestones, underlying massive and in part globulitic limestones, devoid of fossils. According to preliminary information, the fauna consists chiefly of Trilobites of the genera *Agnostus*, *Dorypyge*, ? *Remopleurides*, *Conocephalus*, *Crepicephalus*, and *Anomocare*; two species (*Dorypyge Richthofeni* and *Anomocare planum*) occur also in the fauna of the Wu-lo-pu, and one (*Anomocare majus*) in that of Sai-ma-ki. Accordingly, Gottsche places the marly slates and bituminous limestones upon the same horizon as the Andrarum Limestone, whilst he regards the globulitic limestones, devoid of fossils, as probably of Lower Silurian age; he therefore arrives at almost the opposite conclusion to Dames, who unites the *Dorypyge* strata of Wu-lo-pu with the Lower Silurian, and the globulitic limestones of Ta-ling, as well as the strata of Sai-ma-ki, with the Andrarum Limestone.

Walcott,[3] who places *Dicellocephalus gothicus* and *D. quadriceps* in the genus *Olenoides* (Middle Cambrian), and considers *Dorypyge* to be synonymous with *Olenoides*, regards the whole of the 'fauna of Liautung' as Middle Cambrian, and views the Sinic strata as a development of the Cambrian, entirely corresponding to that of his 'Rocky Mountain province' of Western America. This view is shared on the whole by Trech[4]; he, however, retains *Dorypyge* as distinct from the Lower and Middle Cambrian genus *Olenoides*, though admitting their near relationship; he also quite correctly separates the various faunas of Liautung. The *Dorypyge* strata of Wu-lo-pu are held to be older than the Middle Cambrian limestones of Sai-ma-ki and Ta-ling. Walcott,[5] having in the meantime made known a true *Dorypyge* from the Lower Cambrian of America, Trech points out that the *Dorypyge* strata of Wu-lo-pu may be even of Lower

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[1] *Dorypyge Richthofeni* is given on p. 27 as occurring also at Ta-ling; this in opposition to the remarks contained on p. 31; however, on some specimens in the collection of the 'Museum für Naturkunde,' this locality has been altered by Dames himself into 'Wu-lo-pu.'

[2] "Geologische Skizze von Korea": Sitz.-Ber. d. Ak. d. Wiss. z. Berlin, Jg. 1886, p. 857.

[3] Correlation papers, Cambrian: Bull. U.S. Geol. Surv., No. 81, 1891, p. 377.

[4] Leth. geogn., vol. ii, pt. 1, 1897, p. 58.

[5] 10th Ann. Rep. U.S. Geol. Surv., p. 644.

Cambrian age. Matthew,[1] however, maintains the Middle Cambrian [p. 106] age of the Chinese *Dorypyge*, but regards this genus in a larger sense, viz., as including in part *Olenoides*. In accordance with this view *Dorypyge* would make its appearance in the Lower Cambrian, attain its acme in the Middle, and extend also into the Upper Cambrian.

Recently Bergeron[2] has described a sandstone and a limestone slab from China, which exhibit remains of a quite peculiar new fauna. The sandstone slab comes from the mountains north of Toung-yen-Fou, from a nearly vertically elevated complex of strata, with horizontally deposited Sinic sandstones overlying them; the slab contained only a few remains of a new genus of Trilobites, *Arthricocephalus*. Bergeron does not pronounce on the geological age of the stratum; but from the stratigraphical relations and from the diagrammatic sketch of *Arthricocephalus* (op. cit., p. 515, text-fig. 9), a Lower Cambrian or even a pre-Cambrian age may be assumed.

The limestone slab, which had been bought from a dealer in curiosities in Peking, and was said to come from the mountains to the north of that city, is, according to the photographic illustration (op. cit., pl. xiii), completely covered with remains of Trilobites, referred by Bergeron to the genera *Agnostus* (Regii group), ? *Calymmene, Olenoides*, ? *Dicellocephalus*, and to the new genus *Drepanura*. From what will be said further on, the correct determination of the *Agnostus* and *Olenoides* may be doubted; it is precisely from these forms that Bergeron concludes the Peking slab to be of Middle Cambrian. Concerning the strata of Liautung, Bergeron is of opinion that they cannot be with certainty referred to the Middle Cambrian; in his opinion neither is *Dorypyge* (generically different from *Olenoides*), nor are *Conocephalus*, *Anomocare*, and *Liostracus* characteristic of this horizon. Moreover, in his view, the *Agnostus* (from Sai-ma-ki) is a member of the 'Longifrontes,' which is supposed to have been "trouvé à un niveau inférieur à celui des *Dorypyge*" (from Wu-lo-pu), is suggestive of the Upper Cambrian, where this group is said to reach the maximum of its development.

[p. 107] Considering these divergent views on the age of the Sinic strata, as well as the imperfect knowledge of their faunas, we are under great obligation to Herr Bergmeister F. Koerfer for having collected, amongst others, numerous slabs from the Upper Sinic Limestones with well-preserved fossils. The collections were handed over to the Royal Prussian Geological Survey and 'Bergakademie,' by whom Herr H. Monke states he has been entrusted with the examination of the fossils. One particularly well-preserved slab (reproduced on pl. ix) had been presented to Baron v. Richthofen; this, he says, has also been kindly entrusted to him. The Sinic fossils come from two separate localities,

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[1] Studies on Cambrian Faunas: Trans. R. Soc. Canada, ser. II, vol. iii (1897), p. 186; and vol. v (1899), pp. 56, 62.

[2] "Etude de quelques Trilobites de Chine": Bull. Soc. géol. France, sér. III, *t. 27 (1899), p. 499.*

Wang-tschuang and Yen-tsy-yai, in the province of Shantung, from strata which petrographically and faunistically are totally different. Nothing is known about the particulars of the deposits, Yen-tsy-yai not having been visited by Herr Koerfer, nor, indeed, by any European[1]; the indication of the locality rests solely on the information of the Chinese, from whom the slabs were purchased. In his report[2] Herr Koerfer makes the following remark on this point: "The Palæozoic strata begin in Shantung with an alternation of siliceous limestones, reddish clay-slates, and red or yellow sandstones. On this complex of strata, called Middle Sinic by Von Richthofen, follows the Upper Sinic formation, which is composed almost exclusively of massive beds of limestone, and [p. 108] contains numerous fossils of the primordial fauna. Two deposits deserve special mention. The one is situated near the village Wang-tschuang (between Möng-yin-hsien and Ichui-hsien), where limestone beds densely filled with Trilobites are to be found at about 200 metres above the limit of the Middle Sinic formation of the Valleys. The fossils correspond completely with those collected at Liautung by Von Richthofen.[3] The second deposit is situated one day's journey to the north-west of Wang-tschuang, near the village Yen-tsy-yai, whence beautiful slabs with Trilobites (styled 'petrified swallows'[4] by the Chinese) are put into commerce. These are more recent Trilobites than those of Wang-tschuang, and probably Upper Silurian[3] in age."

Finally, the Shantung Bergbau Gesellschaft at Berlin presented to the Museum of the Geological Survey and Bergakademie two limestone slabs exactly corresponding with those from Yen-tsy-yai, and derived, according to Herr Bergassessor Krause, from the mountainous district N.N.E. of Möng-yin-hsien, which agrees with the information reported above. Unfortunately (owing to an assault made upon him by the Chinese), Herr Krause had to leave behind the majority of his geological collections.

Herr H. Monke then proceeds to describe the Trilobite-bearing limestones and shales of the Yen-tsy-yai; and he states that there will be given in a later paper descriptions of the Brachiopoda of Yen-tsy-yai and of the fauna of Wang-tschuang, together with the general results.

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[1] After the termination of the present memoir I have received the information that Herr Bergassessor Axt has been commissioned by the Schantung Bergbau Gesellschaft at Berlin to survey the neighbourhood of Yen-tsy-yai. The results of his investigations will be reported on a future occasion.

[2] "Geologische Skizze der Provinz Schantung unter Benutzung der Karte von F. v. Richthofen," Berlin, 1891. Printed in the Imperial Typography; 4 pp. and a map. (Short preliminary notice in Zeitschr. d. Deutsch. geol. Ges., vol. lii, 1900, Verh., p. 109.)

[3] This is not correct.

[4] *Drepanura Premesnili*, Bergeron, and *D. Ketteleri*, H. Monke.

(*To be continued.*)

V.—THE OCCURRENCE OF GLACIAL CLAY ON THE COTTESWOLD PLATEAU.

By C. CALLAWAY, D.Sc., F.G.S.

MR. L. RICHARDSON, F.G.S., having informed me that he had seen gravels at a high level on the road leading from Stow-on-the-Wold to Burford, I visited the locality, accompanied by Mr. J. W. Gray, F.G.S. About 3¼ miles north of Burford, at the corner of the turning to Tangley, we came upon a deposit of clay with northern erratics in a quarry of oolite. As the position of such a formation was unexpected, and might be important, it seems desirable to record the discovery.

The Locality.—The deposit lies on the Cotteswold plateau, near its eastern margin, about midway between Cheltenham and Oxford, and about the same distance (18 miles) south-by-east of Meon Hill, the most northerly spur of the Cotteswolds. The elevation is approximately 650 feet above O.D., and 350 feet above the river Evenlode, which lies 2½ miles to the east. The section is on a spur of Oolite about 6 miles long, projecting from the mass of Tainton and Shipton Downs, to the north-north-west, and then curving round to the north-west, rising towards its northerly termination to over 800 feet in Wyck Beacon. From the quarry the ground slopes rather sharply in both directions, to the Evenlode on the east, to a tributary of the Windrush on the west; so that the clay lies on the very apex of a pent-house ridge.

The Clay.—The rock for which the quarry is worked is Great Oolite. It has been excavated along a north and south line parallel with the road for perhaps 50 yards, exposing a vertical section whose maximum height is about 10 feet. The strata dip gently in a westerly direction. The rock is much fissured, the fissures being very irregular, so that at some points they broaden out at the top into wide pockets, while in others they are little more than open joints. Some of the narrow ones go down to the foot of the cliff. All the fissures are packed tight with clay. It has found its way not only down to the lower end of vertical fissures two inches wide, but even horizontally into clefts of less than half of that width.

The clay is stiff and hard. It is of two kinds, grey-blue and brown, the former more compact and finer-grained than the other. They are irregularly intermixed, without the faintest indication of bedding or lamination. The difference of colour is original, and not the result of chemical change subsequent to the intrusion of the clay. This is seen in bulk-analysis and microscopic examination.

The blue clay, triturated with water in a test-tube repeatedly, and allowed to settle, appears to the naked eye an almost pure clay of extremely fine texture. It gives no effervescence with acid. Examined with a one-inch objective, the bulk of the material is still seen to be very minute, but is mixed with a small proportion of larger particles of two kinds, (1) brown sand and (2) very small granules and microliths of clear minerals, some of which have a high refractive index.

The brown clay, treated in the same way, presents very marked differences. More than one-half of it is a quartzose sand of angular and subangular grains stained with a reddish-brown colour, the remainder being a pale-red clay with a small proportion of minute clear minerals.

The Erratics.—These are of all sizes up to 3 inch diameter. The following are the chief varieties:—

(1) Quartz, very much rolled.
(2) Quartzite, (*a*) white and (*b*) grey, well rolled.
(3) Chert, (*a*) white, (*b*) grey, with impressions of small encrinite stems, and (*c*) banded black and white; not so well rolled as the quartz and quartzite; some specimens subangular.
(4) Coarse quartzose grits, grey and reddish (? Millstone-grit); well rounded.
(5) Flints, (*a*) brown with white crust, (*b*) white (? weathered); rounded and subangular; 1 to 2 inches diameter.
(6) Brown ironstone (? Lias Marlstone), small, subangular.
(7) Grey oolite, subangular fragments and numerous spherical grains.
(8) Reddish-brown iron-shot oolite; locality not identified, though a specimen was submitted to several experts.

Derivation of the Materials.—The origin of the clays is not determined with certainty. The blue variety suggests the Lower Lias, while the red sandy clay may have been derived from Keuper Marls and Sandstone.

The pebbles of quartz and quartzite have almost certainly come from Triassic conglomerates north of the Cotteswold area. The cherts and grits are presumably Carboniferous, and may have travelled from Derbyshire. For the flints a north-easterly origin is probable. The ironstone and oolites, with perhaps the blue clay, are the only materials that appear to be of local derivation.

Some light is thrown upon the derivation of the erratics by a study of the deposits which occupy the Evenlode valley and the northerly extension of its axis along the valley of the Stour, which drains into the system of the Warwickshire Avon. Commencing at the southern point, we observe exposures of sand and clay at Milton-under-Wychwood, a mile and a half east of our Tangley section, about 250 feet lower than the section, 100 feet above the Evenlode at Shipton, and 400 feet above O.D. The highest deposit is near the road at Upper Milton. It consists of sands, brown and grey interbedded, excavated to a depth of 10 feet, and overlain by from 1 to 3 feet of brown clay containing quartz pebbles and small angular flints. There is a similar clay in a field to the east at a little lower level. It is 3 to 4 feet thick, and is traversed by a rough vertical jointing. Shaken up in water, it is seen to resemble the brown clay of the Tangley section. About 100 yards distant is a section of clay, with quartzite pebbles, overlying a gravel of small angular pieces of oolite, underlain by red sand. It will be noticed that the uppermost layer in these three sections is a brown sandy clay, not dissimilar to the brown clay of the ridge above.

Passing northwards up the valley, we come to Kingham, 4 miles north of Shipton. Here is exposed a good section of oolite-gravel, with interbedded seams of oolite-sand. The fragments are water-worn. Scattered through the mass are some well-rounded pebbles of quartz, quartzite, and quartzose grit, with some bits of ironstone. Towards the top of the section a few of the quartzite pebbles have their longer axes vertical. Two miles further up the valley, east of Adlestrop station, there are arenaceous gravels, containing many flints, some of them of large size. Near Evenlode, 1¾ miles due north, is the boulder of Millstone-grit indicated on the Geological Survey Map. Its dimensions are 20 by 14 by 14 inches. It is well rounded.

The well-known gravels of Moreton-in-the-Marsh are 2¼ miles further to the north-west. They lie near the water-parting of the Evenlode and the Stour, at an elevation of about 425 feet above O.D. The sandy matrix contains numerous large and small unworn flints and well-rounded quartzite pebbles, with an inconspicuous proportion of igneous and other rocks. Many of the flints and pebbles lie with their longer axes vertical. The valley to the north of Moreton is thickly strewn with similar materials. I also observed boulders of Carboniferous Limestone, grey felsite or hornstone, and other erratics. W. C. Lucy[1] describes the gravels of this district, and he notes the occurrence of other foreign derivatives, including white chalk and red chalk. I have shown some of the latter to Mr. W. Whitaker, and he admits the accuracy of the identification.

The origin of the Moreton gravels has been discussed.[2] Mr. S. S. Buckman leans to the opinion that they were deposited by a river, when the surface features of the country were widely different. The abundance of flints, with a less proportion of white and red chalk, would seem to point to a derivation from Lincolnshire or Yorkshire, but it is difficult to conceive of a downward flow from that direction to the Cotteswold Hills in later Tertiary times. This hypothesis appears also to be inconsistent with the enormous abundance of large unworn flints north of Moreton as compared with their scarcity south of that point. Mr. T. Mellard Reade is disposed to attribute the formation of the Moreton gravels to floating ice in the Glacial Epoch. Some form of the ice-theory is, I think, necessary to explain the facts. Ice in the Midland area moving southwards might well be arrested by the projecting mass of the North Cotteswolds, and morainic matter would accumulate at the opening of the Moreton gorge.

The Tangley section also appears to me inexplicable except as the product of ice-action. It lies on the summit of the ridge, and the materials could not have been river-borne in Glacial or post-Glacial times. The clay is quite unlike an ordinary sediment: not only is lamination absent, but the two kinds of clay are intermixed in the most irregular manner without being blended with each other. They are both traversed by numerous slickensides, some of which are marked with parallel striations and grooves, as if portions of clay had moved over each other. It is difficult to resist the conclusion that the clay has not been deposited in the fissures by water, but has been introduced by pressure when in a partially consolidated condition. An ice-sheet pushing forward clayey morainic material might have conceivably produced the effect, but I hesitate to pronounce a definite opinion on such a limited section.

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[1] Proc. Cotteswold Nat. Field Club, vol. v, pp. 71–142.

[2] Ibid., vol. xiv, pp. 111–118.

W. C. Lucy remarks[1] that clay containing quartz pebbles is scattered "nearly all over the Cotteswold range," sometimes up to a thickness of 3 feet, and often filling pockets in the oolite.

The boulders and some of the gravels and clays found in the Evenlode valley between Shipton and Moreton tend to confirm the evidence of the Tangley section by suggesting the agency of ice, at least as far south as Tangley, at lower levels.

Since writing the above, I have referred to Mr. David's paper[2] "On the Evidence of Glacial Action in South Brecknockshire and East Glamorganshire." He describes the shattering of rocks by ice-action, and states that "boulder-clay has been forced into the shattered strata to a depth of 12 feet at least."

I trust that these notes will attract to the district the attention of those who have made a special study of glacial phenomena.

VI.—On Earth-Shakes in Mining Districts.

By Charles Davison, Sc.D., F.G.S.

THE term 'earth-shake' has been applied to local disturbances of the earth which owe their origin, either in part or wholly, to artificial causes. Typical examples of earth-shakes are those which are occasionally felt at Sunderland and other places on the magnesian limestone of the Durham coast, and which have been attributed by Prof. Lebour to rock-falls in underground channels, enlarged no doubt by pumping in connection with the local water-supply.[3] Other examples are the shocks frequently felt in mining districts, and either caused or precipitated by mining operations. Earth-shakes of this class have occurred in the Rhondda Valley in Glamorganshire on June 22, 1889, April 11 and May 2, 1894, and October 16, 1896; in the neighbourhood of Camborne on June 4 and 10, 1902; at Pendleton, near Manchester, on February 27, 1899, and April 7, 1900; at Kilsyth in Stirlingshire on February 16, 1898, and in various other districts.

The last group of earth-shakes are found to possess certain features in common:—

(1) The disturbed area is small, from one to five miles in diameter; and, as a rule, the boundary is approximately circular in form.

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[1] Ibid., vol. vii, pp. 50-61.

[2] Quart. Journ. Geol. Soc., 1883, p. 39.

[3] "On the Breccia-gashes of the Durham Coast and some Recent Earth-shakes at Sunderland," North of England Inst. of Min. Eng. Trans., vol. xxxiii, 1884, pp. 165–174; "On some Recent Earthquakes on the Durham Coast and their probable Cause," Geol. Mag., Vol. II, 1885, pp. 513-515.

(2) The intensity of the shock is great near the centre of the area, and dies away rapidly towards the boundary.

(3) The shock and sound are of short duration, the sound in four out of every five records being compared either to the fall of a heavy body or to an explosion.

We may infer, from these facts, that the centre of disturbance is situated at a very slight depth below the surface, and also that it is, as a rule, of small dimensions. Falls of rock in pit-workings would satisfy these conditions and would produce shocks very similar to those observed, but none was found on any of the above occasions. Many rock-falls are caused or accompanied by disturbances known in the Staffordshire Colliery districts as 'bumps' or 'goths.' They are probably due to "the sudden release by fracture of a state of tension in the strata either pre-existent or brought about by the mine-workings."[1]

Another probable cause of earth-shakes in mining districts is that suggested in a recent paper in this Magazine.[2] It is noticeable that, in all the above cases, the centres of the disturbed areas lay close to faults; and those of the Pendleton earth-shakes were on the downthrow side of the Irwell Valley fault, the coal having been worked away right up to the fault. By the withdrawal of the coal, the rock above is deprived of most of its support, and tends to sink down and close up the worked-out seam. Especially would this be the case in the neighbourhood of a fault, where a series of small fault-slips would take place, each giving rise to a shock, violent in the district immediately above it but rapidly fading away in strength, and as a rule of brief duration and disturbing a nearly circular area.

Direct proof of the occurrence of such semi-artificial fault-slips could no doubt be afforded only by careful and prolonged observation and experiment; but indirect evidence supporting the above explanation is furnished by three recent earth-shakes, those of Blisland (Cornwall) on August 25, 1895, of Camborne on June 4, 1902, and of Barnsley on October 25, 1903.

BLISLAND EARTH-SHAKE: AUGUST 25, 1895.

Time of occurrence, about 12.30 p.m.; intensity, 4; epicentre, in lat. 50° 31·9′ N., long. 4° 40·9′ W.; number of records, 20, from 19 places, and negative records from 2 places.

The Blisland earth-shake has already been described in this

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[1] W. N. Atkinson, Report of H.M. Inspector of Mines for the Stafford District for the year 1903, p. 15. Mr. Atkinson remarks that the terms 'bump,' 'goth,' etc., refer to "a sort of explosion or eructation in the strata which in some cases is so severe as to be comparable to local earthquakes. They occur chiefly in thick and deep seams, and vary greatly in intensity both as to sound and effect on the strata. The sound is often compared to that of a shot, and appears to occur sometimes in the coal itself and sometimes in the strata overhead; in heavy bumps the sound is more like thunder. The effect of the bumps on the strata varies greatly; in slight cases there is no observable effect except the sound; when more severe there is vibration, and falls of roof may take place, or coal be burst off the face; in severe cases timber is broken or reeled out, and the mine appears to be about to collapse. In some cases the floor bursts up instead of the roof falling."

[2] GEOL. MAG., Vol. VII, 1900, pp. 174–177; Vol. VIII, 1901, p. 361.

Magazine.[1] It disturbed a small, but elongated area, 6 miles long, nearly 2 miles wide, and containing 9 square miles. Its centre is half a mile north of Blisland, and the direction of its longer axis E. 5° N. and W. 5° S. The shock was merely a slight tremor, of intensity 4. The sound was heard by all the observers, and was compared to passing trains, etc., in 33 per cent. of the records, to thunder in 47, and to explosions in 20, per cent. The beginning and end of the sound coincided either quite, or very nearly, with the beginning and end of the shock. No faults are traced on the Geological Survey map in the neighbourhood of the disturbed area; but, close to the centre and southern boundary of the area, are several series of elvan dykes which run almost parallel to the longer axis of the disturbed area.

CAMBORNE EARTH-SHAKE: JUNE 4, 1902.

Time of occurrence, 10.30 p.m.; intensity, 5; epicentre, in lat. 50° 13·4′ N., long. 5° 16·6′ W.; number of records, 22, from 12 places, and 30 negative records from 22 places.

The area affected by this earth-shake is shown in Fig. 1. The boundary, as drawn, is elliptical in form, 4¼ miles long, 3 miles wide, and about 10 square miles in area; the centre being about one mile north-east of the centre of Camborne. It is possible, however, that the boundary should extend a short distance, perhaps as much as half a mile, farther to the west, for there are no negative records from the district immediately to the west of Camborne. The direction of the longer axis is N. 24° W. and S. 24° E.

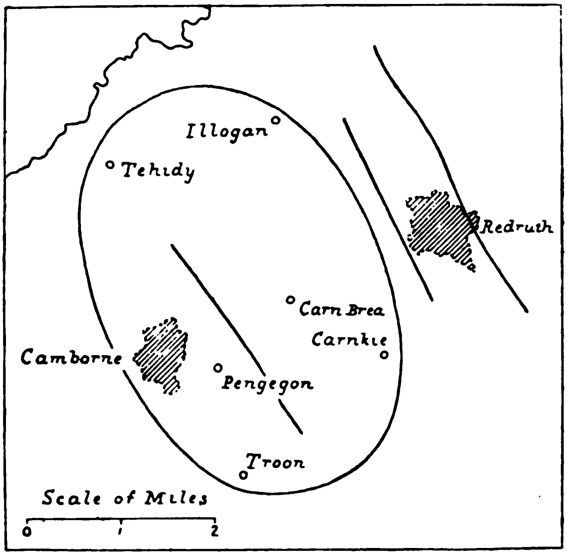

FIG. 1.—Area of the Camborne Earth-shake.

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[1] GEOL. MAG., Dec. IV, Vol. VII, 1900, pp. 164–166.

The shock consisted of one prominent vibration, like that produced by the fall of a heavy weight, followed by a tremulous motion lasting for one or two seconds. The sound was heard by all the observers. In 15 per cent. of the records it was compared to passing vehicles, etc., in 8 per cent. to thunder, in 31 to loads of stones falling, in 15 to the fall of a heavy body, in 23 to explosions, and in 8 per cent. to miscellaneous sounds; three out of every four comparisons being to types of brief duration. In nearly every case the terminal epochs of the sound coincided with those of the shock.

If the earth-shake were due to fault-slipping, the fault must run from about N. 24° W. to S. 24° E. and pass a short distance, between half a mile and a mile, to the north-east of Camborne. As to the hade of the originating fault there is no evidence furnished by the earth-shake. Of the three faults shown on the map (Fig. 1) the more westerly one closely satisfies the assigned conditions. It is the 'great cross course' of the Dolcoath Mine, and passes through a point about ¾ of a mile north-east of Camborne in a direction from N. 33° W. to S. 33° E., heaving the Dolcoath Lode 140 yards to the south. The hade of the fault, as Mr. H. P. Vivian kindly informs me, is practically zero.

BARNSLEY EARTH-SHAKE: OCTOBER 25, 1903.

Time of occurrence, 11.5 p.m.; intensity, 7; epicentre, in lat. 53° 31·3′ N., long. 1° 28·2′ W.; number of records, 13, from 9 places, and 12 negative records from 10 places.

As in the two preceding shocks, the disturbed area (Fig. 2) is elliptical in form. It is 5¾ miles long, 3½ miles wide, and contains 16 square miles. Its centre is almost coincident with the village of Worsborough, and the direction of its longer axis is N. 38° W. and S. 38° E.

The intensity of the shock was 7 at Worsborough and Hoyland, 6 at Worsborough Bridge and Barnsley, and from these places it died away rapidly towards the boundary. The shock consisted of a single series of vibrations lasting from 3 to 5 seconds. The sound was also of brief duration, being compared either to the fall of a heavy body or to thunder. In the pit at Worsborough it was mistaken for that of an explosion.

As will be seen from the map, there are several faults which are parallel, or nearly so, to the longer axis of the disturbed area. The faults are indicated by broken lines, except one, which is in part continuous. This fault hades to the north-east, its direction in the central portion of the disturbed area is N. 41° W. and S. 41° E., and its course at the surface is on the south-west side of the epicentre. It thus satisfies the observed conditions, and satisfies them more closely than any other fault.

The curved line on the map (Fig. 2) represents the outcrop of the Barnsley Coal-bed within the disturbed area. At the Barrow colliery, which is the nearest to Worsborough, the depth of the bed is about 100 yards. Mr. R. Richardson, the manager of the colliery, kindly informs me that practically the whole of the coal in this seam has been worked, and that, under the area affected by the earth-shake, it has been exhausted for at least eight or nine years. The Parkgate, Thorncliffe, and Silkstone seams, which are at depths of about 260, 300, and 360 yards respectively, below the Barnsley bed, have also been worked largely.

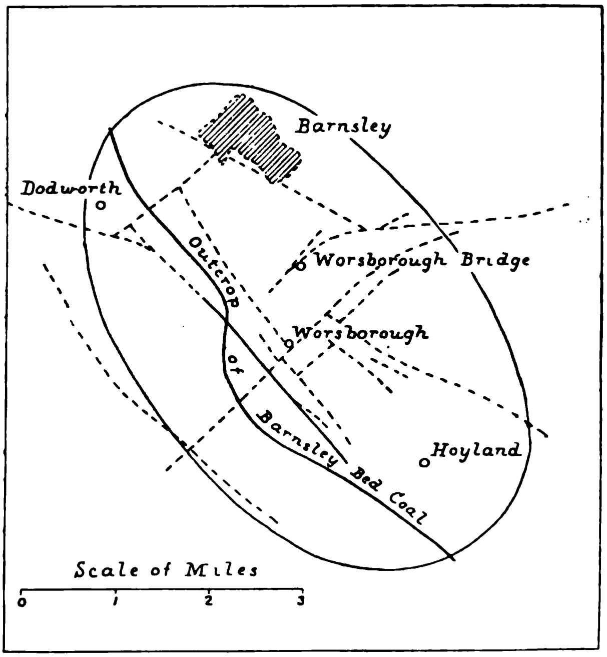

FIG. 2.—Area of the Barnsley Earth-shake.

The areas disturbed by these three earth-shakes are unusually large for this class of disturbance. It would appear, then, that the boundary of the disturbed area is approximately circular in form when the area is small and the shock of slight intensity; but, when the shock is strong and the disturbed area comparatively large, the form of the boundary is distinctly elliptical, and the longer axis of the ellipse is parallel to the neighbouring lines of fault.

The evidence of these shocks thus supports the view that earth-shakes in mining districts are produced by small fault-slips precipitated by the removal of the coal from the immediate neighbourhood of the fault, or partly, perhaps, as Mr. Richardson has suggested to me, by the lowering of the water in that region by pumping in other parts of the mine. In either case—and this is the main point—the earth-shakes would owe their origin to operations of nature, aided very effectively by those of man.

VII.—The Classification of the Phacopidæ.

By F. R. Cowper Reed, M.A., F.G.S., of the Sedgwick Museum, Cambridge.

(*Concluded from p.* 178.)

IN North and South America and in South Africa[1] there is a considerable variety of types of the *Dalmanites*-branch in the Devonian period which have in many cases received distinctive subgeneric names; but species retaining the typical characters of the Silurian forms persist at any rate in North America. Many of these Devonian forms show incomplete second lateral furrows on the glabella, these furrows not reaching the axial furrows and causing a partial coalescence of the two middle lateral lobes. This tendency towards the fusion of the first and second lateral lobes of the glabella is a departure from the perfect segmentation found in typical Silurian members of *Dalmanites,* and has caused Clarke[2] to group all such forms together into the subgenus or section *Synphoria.* This type of structure, as Van Ingen[3] has recently shown, is not unknown amongst the Silurian species of *Dalmanites* in America, but it finds its most pronounced development in Devonian time and occurs in the groups *Coronura, Corycephalus, Odontocephalus,* and *Probolium,* all of which are put by Clarke in the section *Synphoria.* The marginal ornamentation and different processes on the pygidium and head-shield on which these four groups have been founded are scarcely of the same structural importance as the modifications of the glabellar segmentation. As in other families, the spinosity of these forms is the symbol of a last expiring effort before extinction.

Summarising the above facts and deducing therefrom the obvious conclusions, we see that the *Dalmanites*-branch falls into three divisions, which chronologically succeed each other and mark progressive stages of development. Broadly speaking, they may be said to characterise respectively the Ordovician, the Silurian, and the Devonian.

Division I. Primitive and composite forms (e.g., *D. Phillipsi,* Barr., *D. socialis,* Barr., etc.), with pentamerism of head well marked; lobes of glabella distinct; frontal lobe not strongly detached; frontal limb rudimentary or absent; genal angles rounded or shortly pointed; pleuræ of thorax with rounded or pointed ends; pygidium composed of few segments, rarely more than ten, usually of rounded outline. (Subgen. prop. *Dalmanitina*; type, *D. socialis,* Barr.)

Division II. Typical forms (e.g., *D. caudatus,* Brünn., the type of *Dalmanites,* sens. str.), with pentamerism of head well marked; frontal lobe of glabella detached; frontal limb well developed;

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[1] Lake: Annals of the South African Museum, vol. iv, pt. 4, No. 9 (1904), pp. 203-213.

[2] Clarke, "Low. Silur. Trilob. Minnesota": Rep. Geol. Nat. Hist. Surv. Minn., vol. iii (1894), p. 732.

[3] Van Ingen: School of Mines Quarterly, Columbia University, vol. xxiii, Nov. 1901, No. 1, p. 67.

genal angles produced into spines; thoracic pleuræ with pointed ends; pygidium strongly mucronate and of many segments, 12–16 in Silurian species, more than 16 in Devonian. Subgenus *Dalmanites*, sens. str. (=*Hausmannia*).

Division III. Highly specialised forms (e.g. *Asteropyge punctata*, (Stein.)), with pentamerism of head sometimes distinct, sometimes more or less lost by fusion of lobes; genal angles generally spined; margin of head frequently furnished with spines or processes; thoracic pleuræ pointed or produced into spines; pygidium of many segments, 16–20 or more, margin usually ornamented with many spines or processes.[1] The most important character in this division, according to Kayser,[2] is the large number of axial rings in the pygidium, which here reaches the maximum in the family. The members of this division include *Asteropyge*, *Coronura*, *Cryphina*, *Corycephalus*, *Odontocephalus*, *Malladaia*, and *Probolium*. The subgeneric independence of these is open to question, and Clarke's name *Synphoria* would include them all.

Branch B.

The second branch of the Phacopidæ, which culminates in *Phacops*, sens. str., branches off from the primitive division of *Dalmanites* as above stated; and an early stage along this line is found in the *Ph. Glockeri* group of Étage E in Bohemia, which is characterised by the general shortening and widening of the cranidium; the partial loss of the pentamerism; the weakening or obliteration of some of the lateral furrows of the glabella (with the frequent splitting or interruption in the course of the anterior one); the rounding of the genal angles; the increased convexity of the thorax; the rounded or obtuse ends of the pleuræ; the comparatively few segments and the rounded non-mucronate outline of the pygidium; and the general absence of spines. In Northern Europe this stage in the development of the true *Phacops* is represented by the Silurian groups named *Acaste* and *Portlockia*,[3] which possess the above characteristics with minor modifications. The third pair of lateral lobes in the glabella is the most persistent and distinct of the lobes, though often tending to become nodular; and in all the features of this stage we see the beginning of modifications leading up to the Devonian type; but we cannot definitely state that they are in the direct line of evolution of the typical *Phacops*; and the significance of their relatively small size is not at present understood. However, the morphological characters of the *Acaste*, *Portlockia*, and *Ph. Glockeri* groups show a transitional condition, and being confined to the Silurian (with the possible exception of one or two South American[1] and one South African species which are found in the Devonian[2]), it seems to deserve a distinctive subgeneric name, and that of *Phacopidella* is here suggested; type, *Ph. Glockeri*, Barr.

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[1] Barrois has recorded from the Silurian of the Pyrenees a species *Dalmanites Gourdoni*, possessing the short pygidium of 10–11 axial rings, like those in Div. II, but with the margin spinose (Ann. Soc. Géol. Nord, x, 1883, p. 151, pl. vi, fig. 1).

[2] Kayser: Zeitschr. deut. Geol. Gesell., Bd. xxxii (1880), p. 19.

[3] *Portlockia* has no phylogenetic or morphological characters of sufficient value to separate it subgenerically from *Acaste*, as Salter recognised years ago.

The final and most highly specialised stage of this branch is found abundantly in the Devonian period in Europe, America, and Asia, but it appears in the higher part of the Silurian in all three continents and also in Australia.[3] It differs only from the previous stage in the greater accentuation of the above-mentioned characters. The glabella tends to become more enlarged, inflated, and transverse; the pentamerism and segmental furrows become very faint or are quite lost; the lateral lobes of the glabella (excepting generally the nodular basal pair) are inseparably fused; the genal angles and extremities of the thoracic pleuræ are invariably rounded; the pygidium is semicircular or transverse, composed of very few segments, and has a simple regular border. There is a complete absence of spinose ornaments. The eyes in typical *Phacops* are large, but they may be reduced in size or absent (*Trimerocephalus*). Gürich's[4] distinction between *Trimerocephalus* and the typical *Phacops* seems quite insufficient and arbitrary.

This final stage may have the old name *Somatrikelon*[5] revived for it, with *Phacops rana*, Green, as its type.

Branch C.

Lastly, there is the somewhat distinct and disconnected branch of the Phacopidæ of which the earliest types are included in the subgenus *Pterygometopus*.[6] This subgenus appears to be confined to Northern Europe and North America, as Frech has pointed out, and it is characterised by the pentamerous lobation of the head-shield, as we should expect in an early representative of the family, for *Pterygometopus* belongs especially to the lower part of the Ordovician. But there is a constant tendency for the unequal growth of the lateral lobes by the first lobe being developed at the expense of the others; and as the second and third lobes get correspondingly reduced in size by the hypertrophy of the first lobe there is an insensible passage into the condition which marks the subgenus *Chasmops*,[7] in which the second lobe is almost squeezed out or represented by a mere tubercle. The indifferently defined group termed *Homalops*[1] apparently belongs to this stage, and the final result of the extraordinary growth of the first lateral lobes may perhaps be found in *Monorakos*,[2] in which the second and third lateral furrows are only represented by pits. A whole chain of transitional forms showing intermediate conditions between *Pterygometopus* and *Chasmops* can be traced, and there is no hard and fast line between these subgenera. Hall & Clarke[3] diverged widely from the original conception of *Chasmops*, and erroneously interpreted the characters of the type-species by maintaining that the great 'cat's ear' lobes were formed by the coalescence and fusion of the first and second lateral lobes on each side. The definition of the subgenus given by these authors and the species included by them in it cannot therefore be accepted. In all true members of *Chasmops* the second lateral lobes are recognisable and show no coalescence with the first lobes. In the American representatives of *Pterygometopus*, on the other hand, there is, as Clarke[4] has pointed out, a frequent tendency for a coalescence of the first and second lateral lobes, and the culmination of this structural modification seems to be met with in *Monorakos*. For *Pterygometopus* is by no means a homogeneous group, as Schmidt himself has pointed out, and several subdivisions in it may ultimately be recognised, though at present their limits and relations are scarcely well defined.

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[1] Ulrich: Neues Jahrb. f. Miner., Beil. Bd. viii (1893), p. 21 (*Acaste devonica*). Clarke: Archiv. Mus. Nac. Rio de Janeiro, vol. ix (1890), pp. 15–17 (*Ph. brasiliensis*).

[2] Lake: Ann. S. Afr. Mus., vol. iv, pt. 4 (1904), No. 9, p. 205 (*Ph. africanus*).

[3] Etheridge & Mitchell: Proc. Linn. Soc. New South Wales, ser. ii, vol. x (1895), p. 486.

[4] Gürich: Verhandl. russ. kais. Miner. Gesell. St. Petersburg, ser. ii, Bd. xxxii (1896), pp. 359, 362.

[5] McMurtrie: "Sketches of Louisville and the Fall of the Ohio," p. 74 (Louisville, 1819). The type-species of *Somatrikelon* (*S. megalomaton*, McMurtrie) has been identified with *Phacops rana*, Green (Vogdes, Bibliogr. Palæoz. Crust., Occas. Papers Calif. Acad. Sci., No. 4, 1893, p. 163).

[6] Schmidt: Rev. Ostbalt. Silur. Trilob., Abth. i (1881), p. 62.

[7] McCoy: Ann. Mag. Nat. Hist., ser. ii, vol. iv (1849), p. 403.

The connection between *Pterygometopus* and the other branches of the Phacopidæ has not at present been clearly traced, but its relations are undoubtedly wide and varied. Clarke (op. cit.) considers that a Trenton species (*Dalmanites achates*, Billings) is a link between *Dalmanites* and *Pterygometopus*, but his view that lobal coalescence in the glabella is a sign of immature development does not commend itself to me. It may be noted that in many respects, such as the tendency to augment the number of segments in the pygidium and to develop spines on the genal angles, the evolution of the *Dalmanites* and *Pterygometopus* branches has been analogous and parallel. The relations of *Pterygometopus* to *Acaste* (=*Phacopidella*) are also worthy of remark, and Schmidt considers that *Pt. Nieszkowski* forms a passage over to the latter group. The occasional partial loss or reduction of the second lateral furrow of the glabella in *Pterygometopus* (e.g. *Pt. Brongniarti*) is paralleled by certain species of *Acaste* (e.g. *Ph. Downingiæ*).

Proposed Classification.

The results of the above investigation into the relations of the various groups, genera, or subgenera of the Phacopidæ which have been from time to time established show that the following classification may be suggested as based on phylogenetic principles:—

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[1] Remelé: Zeitschr. deut. Geol. Gesell., Bd. xxxvi (1884), p. 200.

[2] Schmidt: Bull. Acad. Impér. Sci. St. Pétersbourg, xii, No. 4 (1886), p. 414.

[3] Hall & Clarke: Palæont. New York, vol. vii (1888), p. 63.

[4] Clarke: Lower Silur. Trilob. Minnesota, 1894, p. 732.

I. Subfamily DALMANITINÆ.
  1. Genus ***Dalmanites***.
    Subgenera ***Dalmanitina***, nom. prop.
    Dalmanites, sens. str. (= ***Hausmannia***).
    Asteropyge
    Odontocephalus
    Coryeephalus
    Malladaia = ***Synphoria***.
    Coronura
    Probolium
    Cryphina

II. Subfamily PHACOPINÆ.
  2. Genus ***Phacops***.
    Subgenera ***Phacopidella***, nom. prop.
    Phacops, sens. str. (= ***Somatrikelon***).
    Trimerocephalus.

III. Subfamily PTERYGOMETOPINÆ.
  3. Genus ***Pterygometopus***.
    Subgenera ***Pterygometopus***, sens. str.
    Chasmops.
    Homalops.
    Monorakos.

The earliest and least differentiated members of each genus are comprised in the subgenera *Dalmanitina*, *Phacopidella*, and *Pterygometopus*, sens. str., and being such have many features in common.

Geographical Distribution.

With regard to their geographical distribution, *Dalmanitina* occurs in the northern and southern provinces of Europe in Ordovician times, but *Pterygometopus* only in the northern. *Phacopidella* was spread over both provinces during Silurian times, though with a slightly different type of development.

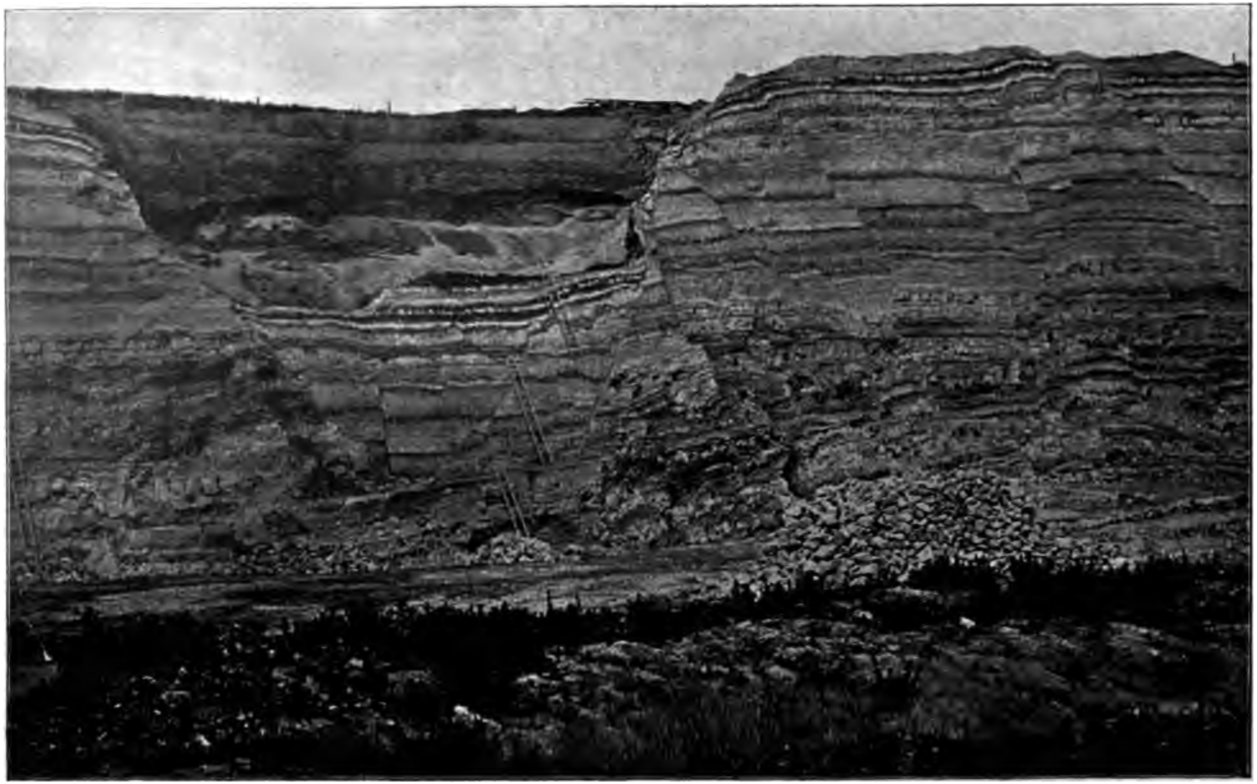
Dalmanites, sens. str. (= *Hausmannia*) was almost solely a northern form during the Silurian period, but during the Devonian period extended also into the south.

The various subgenera of *Dalmanites* in Devonian times were principally developed in North America, but some are found in central and southern and more rarely in northern Europe.

Stratigraphical Distribution.

Stratigraphically the whole of the genus *Pterygometopus* is confined to the Ordovician, and it accomplished its whole range of modifications within the limits of that period.

Dalmanitina is also typically an Ordovician group. *Dalmanites*, sens. str., though principally Silurian, ranged up into the Devonian. *Phacopidella* is Silurian, and the typical *Phacops*, sens. str., appears in the Silurian but reaches its maximum in the Devonian. The whole family became extinct before the dawn of the Carboniferous.



SECTION NEAR WIESBADEN

NOTICES OF MEMOIRS, ETC.

I.—GEOLOGICAL OBSERVATIONS IN THE DISTRICT OF THE ANCIENT CHANNELS BY WHICH THE MAIN AND NECKAR FLOWED INTO THE RHINE NEAR WIESBADEN.

"GEOLOGISCHE BEOBACHTUNGEN IM GEBIET DER ALTEN MÜNDUNGEN VON MAIN UND NECKAR IN DEN RHEIN." Von A. STEUER.

(PLATE XI.)

THE accompanying photographic plate gives a good example of faulting in the Rhine Valley near Wiesbaden in the Pleistocene period. The section in a large quarry south-east of Wiesbaden, south of Mosbach, was photographed during a recent survey of the district by Herr Steuer, but other instances had long been known.

On the right-hand side are shown the Hydrobia deposits (Miocene) covered by a thin layer of old river terrace, the Mosbach Sands. The contrast between the hard calcareous beds and layers of marl with Hydrobia brings out the faulting very clearly. On the left-hand side a large 'wedge' of the sands is let down 10 metres into the underlying marls, bringing Pleistocene deposits sharply against Tertiary. Many small faults may be seen both inside the wedge and in other parts of the section.

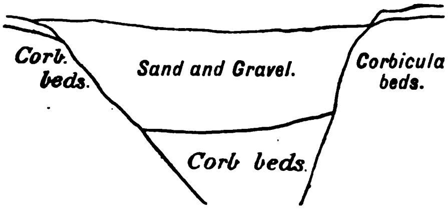


Diagram showing a large wedge of Mosbach Sands and Gravel of Glacial age, which have been let down, by faulting, 10 metres into the underlying marls of Miocene age with *Corbicula* and *Hydrobia* of the Mayence basin. (See centre of Plate XI.)

The Mosbach Sands have yielded *Ursus spelæus, Elephas primigenius, E. antiquus, Cervus canadensis, Alces latifrons, Rhinoceros Mercki, Bison priscus*, etc.

The old terraces of the Maine near its confluence with the Rhine are divided into three. The earliest, corresponding to the Mosbach Sands, is found at about 450 feet above the sea-level, or 200 feet above the present river. But subsequent earth-movements have displaced it to such an extent that it is occasionally seen 150 feet below its normal level. The next terrace is not found in the special district described by the author, but the third, and lowest, forms a narrow belt along the river side not very far above the present flood-levels.

The greatest earth-movements are believed to have taken place between the formation of the second and third terraces, but from the evidence given by the old channels in the youngest terrace it is inferred that the movements were repeated after that epoch, and are perhaps not yet ended.

The oldest terrace is now regarded as Lower Diluvium, the others belonging to the two divisions of the Middle Diluvium. This classification differs somewhat from that published by Dr. Kinkelin, and makes the terraces contemporaneous with older stages of the Alpine Glacial Series.

T. I. POCOCK.

II.—REPORT ON THORIANITE AND THORITE. By ANANDA K. COOMÁRASWÁMY, B.Sc., Director, Mineralogical Survey, Ceylon.

THIS report gives more precise details than have hitherto appeared of the locality and associations of the new mineral thorianite. This mineral, it will be remembered, was shown to be a new species by the analysis of Mr. G. S. Blake, of the Imperial Institute, who found that it contained as much as 76 per cent. of thoria and only about 12 per cent. of oxide of uranium, and thus differed materially from pitchblende, to which it had been at first referred. As shown on a map, which accompanies the report, the principal deposits of thorianite occur in and near the bed of the Kuda Pandi-oya, a small stream near Kondurugala, Bambarabotuwa, Province of Sabaragamuwa, Ceylon. The mineral occurs in the bed of the stream in black cubic crystals associated with zircon and ilmenite. In this neighbourhood it has not yet been discovered *in situ*, but a few crystals have been found in a pegmatite vein on Ambalawa Estate, Gampola.

Mr. Coomáraswámy discusses the prospect of further discoveries, and we wish him success in his efforts in search of these deposits of minerals rich in thoria, now so valuable as the chief constituent of incandescent gas mantles.

REVIEWS.

I.—THE FACE OF THE EARTH. By EDUARD SUESS, Professor of Geology in the University of Vienna. Translated by HERTHA B. C. SOLLAS, Ph.D., of Newnham College; under the direction of Professor W. J. SOLLAS, LL.D., F.R.S., etc. Vol. I. 8vo; pp. xii, 604, with 4 maps, 2 plates, and 48 other illustrations. (Oxford: at the Clarendon Press, 1904. Price 25*s.* net.)

AFTER a period of more than twenty years the first volume of the famous and now classic work of Professor Suess, "Das Antlitz der Erde" (1883–85), has been made intelligible to every British geologist. The work meanwhile, by its broad and luminous teachings, has inspired many a distinguished geologist at home and abroad on all subjects connected with the surface-structure of the earth, and has largely increased our knowledge of the origin of the physical features in which both geologists and geographers are interested.

In the preface which the author has specially written for this translation he points out naturally enough "that the reader will meet, here and there, in the first two volumes, with a description eady antiquated." Here the translator and editor might well e assisted the student by inserting, in square brackets, references he more important works that supplement and in some instances rect former views. To British readers this want is specially iceable in the accounts of the volcanic phenomena of the Inner brides (pp. 155–157) and in the references to South African logy.

nother serious omission is that of an index. With the bability of three other volumes, and the possibility only of fifth volume, consisting of index and geological maps," many rs must elapse before this first volume will be as useful as it ght and ought to be for reference. In other respects we have hing but praise for the care and pains bestowed on the translation Miss Hertha Sollas, and for the undoubted success with which, ed by her father, Professor Sollas, she has so clearly and hfully expressed in English the ofttimes difficult language of original.

he work contains in the introduction a sketch of the shapes of continents and oceans, together with remarks on great earth- vements, on stratigraphical formations, and on the distribution life. The main portion of the volume is divided into two parts. e first treats of the movements in the outer crust of the earth. e Deluge is discussed as the greatest natural phenomenon of ich we have record. Delta deposits, earthquakes and volcanoes, l the relations which may exist between the sensible movements the earth and the phenomena of dislocation, all receive notice.

n the second part accounts are given of the structure and history a number of mountain chains—the Carpathians and the Alps, the untains of India and other parts of Asia, and those of America. e basins of the Adriatic and the Mediterranean, the great deserts, l other prominent features are dealt with. In short, a general ount is given of the structure of the earth's surface, and the scription of the continental masses is followed by a detailed position of the difference which exists between the Pacific and lantic basins.

By using a slightly closer type the present work occupies 604 tead of 778 pages as in the original, but the print is clear and ellent in all respects, while the text-illustrations and the oured maps are in no respect inferior, and in some cases much arer, than in the original edition. It is a handsome volume, and one which should find a welcome place in the library of every rking geologist.

—*CLEIOCRINUS.* By FRANK SPRINGER. Mem. Mus. Comp. Zool. Harvard, vol. xxv, pp. 93–114, one plate. (Cambridge, U.S.A.; January, 1905.)

HE Ordovician genus *Cleiocrinus*, E. Billings, has always been a puzzle to those whom Mr. Springer calls 'Crinologists.' The ucture of the stem and the lateral union of the arms have led ent writers to refer it provisionally to the Flexibilia Impinnata or Ichthyocrinidæ (*sensu latiore*). The composition of the cup was unknown, but was seen to be peculiar; by careful dissection and preparation of specimens belonging to the Geological Survey of Canada, Mr. Springer has now been able to show that it consists of 5 infrabasals, 5 basals, and 5 radials, followed by a large series of fixed brachials and pinnulars, as well as by a vertical series of anals resting on the posterior basal. The peculiarity lies in the facts that the basal and radial circlets have been pushed down over the infrabasal circlet and top of the stem, and that in this process the radials have been separated, while the basals have been pushed up between them so as to support the first primibrachs on their shoulders. Mr. Springer also shows that the arms are pinnulate, a fact mentioned by Billings in obscure fashion but hitherto overlooked; and he states that the angles of both stem and lumen are interradial, instead of alternating as is the case in later crinoids. The conclusion of his most interesting research is "that *Cleiocrinus* is evidently an intermediate form between the Camerata and the Flexibilia," and in this respect he associates it with *Reteocrinus*. His precise intention, however, is not clear, and since he "looks for enlightenment" to phylogenists on this side of the Atlantic, a few suggestions may be welcome. The word "intermediate" can hardly be meant to imply either that the Camerata were evolved from the Flexibilia by way of *Cleiocrinus*, etc., or *vice versa*. The pinnulate stage of arm-structure found in *Cleiocrinus* was not approached by Flexibilia until the Carboniferous Epoch; on the other hand, the infrabasal circlet, in its complete retention of pentamerism, is more primitive than that of any known Flexibilia. Whatever be the origin of *Cleiocrinus*, we must therefore suppose that the Ichthyocrinoid character of direct lateral union of the arms has been independently acquired and no more proves a relationship to the Flexibilia than it does to the still more similar *Uintacrinus*. The composition of the cup and of the arms would allow us to place *Cleiocrinus* with the dicyclic Camerata or Inadunata; but pinnulation was not attained by any Inadunate crinoid before the Middle or Upper Silurian, while the lateral union of the arms is opposed to the general trend of Inadunate evolution. Therefore it seems most simple to place *Cleiocrinus* with the Dicyclic Camerata, from known representatives of which it differs in the suppression of interbrachials. On this ground it is necessary to erect for it a fourth family, CLEIOCRINIDÆ, contemporaneous in its first appearance with Reteocrinidæ and Rhodocrinidæ, but, unlike them, producing no descendants. The structure of the base remains without precedent and, with our present knowledge, inexplicable; but it is hard to believe that the angular shape of the lower margins of the radials is reminiscent of their former position above the basals: is it not rather a downward prolongation such as we find in *Pentacrinus* (= *Extracrinus*)? The only approach to the structure in other respects is the familiar invagination of the base, as seen in the contemporary *Archæocrinus*, and the most probable hypothesis seems to be that the base of *Cleiocrinus* is an exaggeration of this type.

Mr. Springer is heartily to be congratulated on having elucidated this obscure form in his usual masterly manner, and on having thus posed fresh problems. The only fault to be found with the paper is that the area of the pages (36 × 28 cm.) is out of all proportion to their number.
F. A. BATHER.

III.—THE CLAYS AND CLAY INDUSTRY OF NEW JERSEY. By HEINRICH RIES and H. B. KÜMMEL, assisted by G. N. KNAPP. Vol. VI of the Final Report of the State Geologist. Trenton, New Jersey, 1904. Royal 8vo; pp. xxvii, 548. Plates and maps, lvi; figures in text, 41.

IN this Report a very full and complete description of the various clay deposits in the State of New Jersey is given, and their origin, modes of occurrence, physical and chemical properties are discussed in considerable detail. It also contains a large amount of definite and practical information relating to the economic value and the various methods of manufacture suitable to the different kinds of clays, which makes it a reliable work of reference for all those engaged in this industry.

The clay deposits worked belong to various formations. In the northern part of the State there are extensive beds of late Glacial age apparently laid down in lake basins or estuaries by streams issuing from the margin of the great ice field which covered northern New Jersey. Cliffs of clay on the Atlantic coast and terraces bordering the river valleys, 30–50 feet above tide, are referred to the same period. The clay beds are frequently overlain by stratified sand and gravel, and in some places by glacial till. Of the clays of the Tertiary formation may be mentioned those near Bridgeton, which are regarded as of Upper Miocene or Pliocene age on the evidence of plant remains in the associated sandstones. The most important clay deposits in the State are of Lower Cretaceous age, and are known as the Raritan or Plastic Clay series. They are of considerable thickness, and they extend quite across the State from Perth Amboy to Trenton, and thence down the Delaware River. They were probably laid down in an estuary; the only fossils found in them are a few shells of brackish-water character. The beds vary from a white to steel-blue fireclay of considerable economic importance to black sandy clay used for ordinary bricks. A great drawback to working these clays is the thickness of the gravels and, in places, glacial drift, by which they are often capped. These Lower Cretaceous clays rest on beds of Triassic age.

Several excellent maps and numerous illustrations greatly add to the value of this Report.

REPORTS AND PROCEEDINGS.

GEOLOGICAL SOCIETY OF LONDON.

.—March 8th, 1905.—J. E. Marr, Sc.D., F.R.S., President, in the Chair. The following communications were read:—

1. "Observations on some of the Loxonematidæ, with Descriptions

of two New Species." By Miss Jane Donald. (Communicated by Professor Theodore Groom, M.A., D.Sc., F.G.S.)

Shells having more convex whorls, or less sigmoidal lines of growth than *L. sinuosum*, cannot be left within the genus *Loxonema*. The two new species described resemble the type in form and in the sinuosity of the lines of growth; but the whorls are ornamented with spiral striæ, two of which frequently stand out and give the shell a banded appearance. Both species are of Silurian age: one was obtained from the Aymestry Limestone near Ledbury, and from beds of about the same age at Llangadock; and the other from the Wenlock Limestone, Dudley.

2. "On some Gasteropoda from the Silurian Rocks of Llangadock (Caermarthenshire)." By Miss Jane Donald. (Communicated by Professor Theodore Groom, M.A., D.Sc., F.G.S.)

These fossils occur almost entirely in the state of casts and moulds. Eleven distinct forms have been made out, referable to some genera; but only seven are sufficiently well preserved for specific determination. Five of these are new, including one described in the previous communication; a new genus is described, for the reception of *Euomphalus funatus*. The first species described comes nearest to examples placed in the genus *Plethospira*, as represented by *Pl. Semele*, with which it might be placed in a new subgenus. Three other species, including two new ones, resemble shells referred to *Bembexia*. The three species are turriculated, and the band is situated on the angle of the whorls, a little distance above the suture. The specimens described come from the horizons of the Upper Llandovery, the Wenlock, the Lower Ludlow (including the Aymestry Limestone), and the Upper Ludlow.

II.—March 22nd, 1905.—J. E. Marr, Sc.D., F.R.S., President, in the Chair. The following communications were read:—

1. "An Experiment in Mountain-building: Part II." By the Right Hon. the Lord Avebury, P.C., F.R.S., P.S.A., F.G.S.

In this paper some experiments are described which were conducted by an apparatus by means of which pressures could be applied in two directions at right angles to one another, a space of 2 feet square being reduced to one 22 inches square. In the first series, plastic materials such as cloth and thin oilcloth were used, with layers of sand between them. Two main folds crossing at right angles were formed, the upper one shifted over the lower. The use of two layers of linoleum produced a different type of folding, and the lower layers of the linoleum were broken along the principal ridges. In the second series a layer of plaster was introduced; this was found to be fractured, tilted up into a 'writing-desk' form, and forced irregularly into the sandy layers. Overthrusts were thus produced, so that in some cases a boring would have passed through two or even four layers of the rigid substance. In other cases the edges of the primary fracture broke off more or less regularly, and the detached pieces were pushed up, assuming gradually a very steep angle. The remainder of the edges of the plate of plaster, having now room, were able to approach each other. Pliable material above the plaster was thrown into one or a few extensive folds, while that beneath assumed a greater number of small folds.

2. "The Rhætic Rocks of Monmouthshire." By Linsdall Richardson, F.G.S.

The Rhætic rocks occur only in the neighbourhood of Newport; and the present paper describes three new sections and four new exposures. They are the following: Goldcliff, Bishton, Llanmartin, Llanwern, Milton, Bishpool, and Lis-Werry. Measured sections are given at each locality, that at Goldcliff being especially full in the middle portion of the series, because when visited by the author it was exposed in consequence of a breach in the sea-wall. The plane of separation between the 'Tea-green Marls' (Keuper) and the Black Shales of the Rhætic is very definite, and is not infrequently accompanied by an inch or two of conglomerate. The Rhætic ocean appears to have spread with comparative rapidity over the flats of the 'Tea-green Marl' in this neighbourhood. The most complete sequence from Keuper to Rhætic is around Cardiff, where the 'Sully Beds' (Etheridge's 'Grey Marls': not the 'Tea-green Marls,' which belong to the Keuper) constitute transition-beds formed where deposition proceeded continuously. Farther north the 'Black Shales' overstep on to lower and lower portions of the 'Tea-green Marls.' A non-sequence appears to occur at the base of the Paper Shales at Goldcliff, where the upper surface of the Cotham Marble equivalent is conspicuously water-worn.

III.—April 5th, 1905.—J. E. Marr, Sc.D., F.R.S., President, in the Chair. The following communications were read:—

1. "On the Divisions and Correlation of the Upper Portion of the Coal-measures, with special reference to their Development in the Midland Counties of England." By Robert Kidston, F.R.S. L. & E., F.G.S.

The following classification of the Coal-measures is proposed by the author:—

Proposed Names.		*Names previously used.*
4. Radstockian Series	=	Upper Coal-measures.
3. Staffordian Series	=	Transition Series.
2. Westphalian Series	=	Middle Coal-measures.
1. Lanarkian Series	=	Lower Coal-measures (including the Millstone Grit).

The Staffordian Series includes the Blackband Group, beginning with the Bassey Mine Ironstone, the Etruria Marl Group, nearly barren of plant-remains, and the Newcastle-under-Lyme Group. The Radstockian Series includes the Keele Group and various beds in the Midland Coalfields hitherto referred to the Permian System. A classified table is given of all the plants known from the two upper series in the Potteries Coalfield, and a list of those observed in the Newstead boring, Trentham. The plant-yielding beds in the shaft of the Hamstead Colliery, near Birmingham, between the depths of 243 and 411 yards from the surface, are undoubtedly referable to the Radstockian Series and to the Keele Group of the Potteries Coalfield; and the beds without plants, from 209 yards downward, belong to the same group. A bed at 440 yards is referable to the Newcastle Group. A list of these plants is given. These two series are recognizable in Denbighshire; and the Ruabon Marls of the Staffordian Series are as barren in plant-remains as the corresponding Etruria Marls. A list is also given from red and purple shales in Cumberland, which contain Upper Coal-measure plants. Part of the Ardwick Series of Manchester belongs to the Staffordian Series. A table of all plants known from the two upper series (3 and 4) is next given, the distribution of species in the four subdivisions is analysed, and the differences between the two series are discussed. Finally, a list of plants from the Bradford Colliery, Manchester, from shales extending from 8 to 107 yards above the "Bradford Four-Foot Coal," is appended, and the beds are placed in the Staffordian Series; while the species from shale immediately below this coal and from shale 88 yards lower down are classed with the Westphalian Series.

2. "On the Age and Relations of the Phosphatic Chalk of Taplow." By Harold J. Osborne White, F.G.S., and Llewellyn Treacher, F.G.S.

The paper opens with an account of the work hitherto accomplished in the Phosphatic Chalk of Taplow, and especially of the work of Mr. Strahan. The rocks at this locality are then described in detail, and the following classification is adopted:—

		Feet.
E.	Upper White Chalk	(visible) 16
D.	Upper Brown Chalk, or rich phosphatic band	about 8
C.	Middle White Chalk	,, 16
B.	Lower Brown Chalk, or rich phosphatic band	,, 4
A.	Lower White Chalk	(visible) 17

The Lower White Chalk includes a thin layer of tabular flint and one of elongated nodular flints, and the first signs of phosphatic material were observed a few inches below the tabular seam. Attention is drawn to the presence of phosphatic nodules and concretions at certain horizons. Fossil lists are given from each of the above divisions; and the authors conclude that the Lower White Chalk belongs to the zone of *Micraster cor-anguinum*, and the succeeding beds to that of *Marsupites testudinarius*; while the lower phosphate-band represents the lower part of the *Uintacrinus*-band, and the upper one that of the *Marsupites*-band of that zone. In each phosphate-band the base is quite sharp, being defined by a rock-bed in the Chalk; but the upper limit is very ill-marked. The Middle White Chalk is in part divided into lenticles with slickensided surfaces. The authors find *Actinocamax verus* in B, and *A. granulatus* in D and E, but not *A. quadratus* in any bed. Phosphatization is not confined to the Foraminifera and other microscopic remains, but occurs in all shells and structures which are readily penetrable, ıgh not so markedly in those of a more homogeneous character. *ria* occurs in division E, the upper part of which may possibly nolude the base of the zone of *Actinocamax quadratus*, or at ate may not be many feet below that base. The distribution, rical proportion, and, to some extent also, the morphological oter of the macroscopic fossils of the Phosphatic Chalk are tional. The majority of the French deposits of Senonian age ır to belong to a distinctly higher horizon. The authors give nce to show that a part, at least, of the phosphatized material quired its distinctive mineralogical character on the spot. So ı can be ascertained from existing data, the Phosphatic Chalk fined to a small tract of country measuring less than 3½ miles north-east to south-west by less than 1 mile from north-west to -east. It occurs as an intercalation between the normal Chalk he Lower Eocene (Reading) Beds, and occupies a structural h which coincides with, and is probably due to, a synclinal re.

NERALOGICAL SOCIETY, March 15th, 1905. Professor H. A. ι, F.R.S., President, in the chair.—Description of the big ond recently found at the Premier Mine, Transvaal: by '. H. Hatch and Dr. G. S. Corstorphine. The stone weighed 1¼ lbs., and its greatest linear dimension was 4 inches. It was (probably less than half) of a distorted octahedral crystal.—On new mineral localities in Cornwall and Devon: by A. E. I. M. ell. An account was given of various new finds of the minerals se, scheelite, wolframite, childrenite, apatite, and connellite.—ι crystal of phenakite from Africa: by L. J. Spencer. This al, which was transparent and rich in faces, was brought back her with crystals of tourmaline, corundum, and amethyst, by lev. A. North Wood from the Usagara Country in German East a.—Notes on various minerals from the Binnenthal, Switzerland: . T. Prior and G. F. Herbert Smith. Further crystallographic hemical details were given of the three new red minerals from Binnenthal, originally described by R. H. Solly, and named by Smithite (after G. F. Herbert Smith), Hutchinsonite (after Iutchinson), and Trechmannite (after C. O. Trechmann). hite is a sulpharsenite of silver, having the composition repre-d by the formula $AgAsS_2$; it is monoclinic with $a:b:c = $)5 : 1 : 1·9570, β 78° 40′. A perfect cleavage parallel to 100 ıguishes it from the other two red minerals. Hutchinsonite is ıbic with $a:b:c = 1{\cdot}6356:1:0{\cdot}7540$. A prominent form is Trechmannite is rhombohedral with $c = 0{\cdot}7265$. The netry is the same as that of quartz.—On a new oxychloride of er from Sierra Gorda, Chili: by G. T. Prior and G. F. Herbert h. This new mineral, to which the name Paratacamite was ı, has the same chemical composition as atacamite, but begins e its water at a higher temperature than that mineral. It is lorhombohedral with $rr' = 83°$ nearly. Twins about r are non. It displays optical anomalies, for minute fragments under the microscope are found to be biaxial.—On Dundasite from Nor Wales: by G. T. Prior. The mineral was found by Mr. H. Collins in the Welsh Foxdale mine, Trefriw, Carnarvonshire; occurs in white silky radiating tufts on cerussite with allophane, analysis showed it to be identical with dundasite, hitherto known only from Dundas. Tasmania. A probable formula is $PbO . Al_2O_3 . 2CO_2 . 4H_2O$ or $PbH_2(CO_3)_2 . Al_2 . OH_6$.

CORRESPONDENCE.

GRAPTOLITE ZONES IN THE ARENIG ROCKS OF WALES.

Sir,—It has been brought to my notice that in my paper on "Graptolite Zones in the Arenig Rocks of Wales," I have omitted a reference to a paper by the late Mr. T. Roberts, which was published in 1893, Quart. Journ. Geol. Soc., p. 166. I hope I made it clear that I fully recognised the value of Mr. Roberts' work, but I regret the unintentional oversight.

Gertrude L. Elles.

Sedgwick Museum, Cambridge.

LOWER GREENSAND FORAMINIFERA FROM LITTLE COXWELL, NEAR FARINGDON.

Sir,—A book entitled "The Neocomien Sponges, Bryozoa, Foraminifera, and other fossils of the Sponge-gravel Beds of Little Coxwell, near Faringdon," by E. C. Davey, has just been published. It gives much new and interesting information regarding the fossils of the deposit. It was only of recent years, however, that the author became aware of Foraminifera occurring in the gravels; the credit of this discovery, he tells us, is solely due to Mr. F. Mockler, of the Holburn Museum, Bath. The Foraminifera were sent to me to be named. They consisted of a large number of specimens belonging to 53 different species, some of them being rare and interesting forms, and all or nearly all of them being now recorded from the place for the first time. It is, however, to be regretted that the proof was not sent to me for correction; the list is valuable, but as it is now printed contains a number of errors as regards the Foraminifera, and as it would be most desirable that it should be accurately given to be of use to others, I would be much obliged if you would kindly publish in the Geological Magazine the corrected list which I now enclose.

Foraminifera.

c. = common. v.c. = very common. r. = rare. v.r. = very rare.

Cornuspira cretacea, Rss. v.r.
Placopsilina cenomana, d'Orb. Specimens large. Frequent.
Haplostiche Soldanii (J. & P.). v.r.
Thuramminopsis canaliculata, Haensler. v.r.
Cyclammina cancellata, Brady. c.
Ammodiscus gordialis, J. & P. v.r.
Gaudryina oxycona, Rss. v.c.
Bulimina pupoides, d'Orb. v.r.
Bolivina tegulata, Rss. One specimen.
Lagena globosa (Montagu). v.r.
Nodosaria (*Gl.*) *æqualis*, Rss. v.r.
N. calomorpha, Rss. One specimen.

Nodosaria (*D.*) *pauperata*, d'Orb. Specimens not typical. v.r.
N. (*D.*) *consobrina*, d'Orb. r.
N. farcimen (Sold.). v.r.
N. (*D.*) *communis*, d'Orb. r.
N. (*D.*) *Roemeri*, Neug. v.r.
N. (*D.*) *mucronata*, Neug. v.r.
N. comata (Batsch). Slender form. v.r.
N. raphanus (Linné). v.r.
Lingulina carinata, d'Orb. Variety with segments slightly compressed. v.r.
Rhabdogonium tricarinatum (d'Orb.). Broken specimens. r.
R. Budensis (Hantk.). c.
R. globuliferum, Rss. v.r.
Marginulina Wetherellii, Jones. v.r.
Vaginulina legumen (Linné). r.
V. linearis (Montagu). One specimen.
V. arguta, Rss. r.
V. harpa, Roem. c.
V. striata, d'Orb. r.
V. marginuloides, Rss. One specimen.
V. recta, Rss. v.r.
Cristellaria rotulata (Montf.). v.c.
C. gibba, d'Orb. c.
Cristellaria crepidula (F. & M.). c.
C. lata (Cornuel). One specimen.
C. ensis (Rss.). r.
C. Italica (Defr.). v.r.
C. Schloenbachi, Rss. v.r.
C. acutauricularis (F. &. M.). v.r.
C. sulcifera, Rss. r.
C. subalata, Rss. r.
Flabellina rugosa, d'Orb. Some of the specimens are very fine. c.
Polymorphina communis, d'Orb. One specimen.
P. lanceolata, Rss. Specimens in poor condition. r.
P. sororia, Rss. One fistulose form.
P. regina, B., P., & J. One broken specimen.
Ramulina globulifera, Brady. c.
Vitrowebbina irregularis (d'Orb.). v.r.
Spirillina margaritifera, Will. v.c.
Patellina corrugata, Will. c.
Discorbina orbicularis (Terq.). Specimens intermediate between *D. orbicularis* and *D. globularis*. c.
Rotalia orbicularis, d'Orb. One specimen.

JOSEPH WRIGHT.

4, ALFRED STREET, BELFAST.
April 11th, 1905.

THE FORMATION OF CIRQUES.

SIR,—Will you kindly give me a little space in which to correct a mistake I have made on p. 437 of vol. i of my new book, in which I have done a double injustice, one to my friend Professor Bonney and the other to myself.

In discussing the theory of the ice excavation of cirques I mention him as a champion of the notion, whereas, as is perfectly plain from his writings, he opposes that theory, so that he is on my side entirely instead of against me on this point.

The fact is the reference to Professor Bonney ought to have been inserted in an earlier chapter and in reference to the aqueous erosion of cirques, a view he does endorse, while I feel obliged to side with Falsan and the other French geologists who have studied the great cirques of the Pyrenees and attribute them to deformations and otherwise original structural features imposed on the upper Alpine and other valleys at the time the contour of the mountain ranges was first given to them. As it is my practice always to correct my errors when they have been pointed out, I take the first opportunity of putting this small slip right, and it is particularly pleasant to me since I gain a powerful friend to my side of the argument by doing so.

HENRY H. HOWORTH.

30, COLLINGHAM PLACE,
CROMWELL ROAD, S.W.
April 17th, 1905.

OBITUARY.

HENRY BENEDICT MEDLICOTT, M.A., F.R.S.

BORN AUGUST 3, 1829. DIED APRIL 6, 1905.

MR. MEDLICOTT was the second son of the Rev. Samuel Medlicott, Rector of Loughrea, co. Galway, and was born in that parish. He was educated at Trinity College, Dublin, and in 1851 he was appointed to the Geological Survey in Ireland. In 1853 he was transferred to the English branch of the Geological Survey, and worked until the close of the year with Aveline in the Vale of Pewsey and other parts of Wiltshire. Late in the same year he was appointed on the staff of the Indian Geological Survey, and commenced duties in 1854. During that year he was also chosen Professor of Geology at the Thomason College of Engineering at Roorkee. Mr. Medlicott became Superintendent (and afterwards Director) of the Geological Survey of India in 1876, and served in that capacity until he retired in 1887. His geological work related almost wholly to India and is published in the Memoirs and Records of the Geological Survey of that country.

In conjunction with Dr. W. T. Blanford he brought out in 1879 the well-known "Manual of the Geology of India," which summarized all that was known of the country at that date. Otherwise his published works are not numerous. He communicated in 1867 to the Geological Society of London a paper on "The Alps and the Himalayas: a Geological Comparison" (Quart. Journ. Geol. Soc., vol. xxiv, pp. 34–52). He was author also of a work entitled "Evolution of Mind in Man," 1892.

In 1888, shortly after his retirement from the public service, he was awarded the Wollaston Medal by the Council of the Geological Society. From this date he resided for the most part at Clifton, near Bristol, where he died at the age of 76.

MISCELLANEOUS.

TORQUAY NATURAL HISTORY SOCIETY.—Mr. Alexander Somervail, the Curator of the Torquay Natural History Society, reports that the following important addition has been made to the Museum by Mr. J. G. Hamling, F.G.S., of The Close, Barnstaple, who has presented his valuable collection of Devonian and Culm fossils of North Devon to the Society's Museum. The collection consists of about a thousand specimens illustrative of these two geological formations. It is in North Devon where the Devonian formation is fully developed, its upper portion being almost absent in the South. The upper division consists of the Pickwell, Baggy, and Pilton groups, each characterised by its own distinctive fossil remains. The Culm (or Carboniferous) formation is also more fully represented in North Devon, and its fossils are more numerous and varied. The whole collection will prove a most valuable *acquisition.*

THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE V. VOL. II.

No. VI.—JUNE, 1905.

ORIGINAL ARTICLES.

I.—NOTES ON BRITISH DINOSAURS. PART II: *POLACANTHUS*.

By Dr. FRANCIS BARON NOPCSA.

(PLATE XII.)

NEXT to *Hypsilophodon*[1] it was *Polacanthus* which attracted my attention. A careful study soon showed that, after the death of the animal, the remains of some Crocodilian had accidentally become commingled with this Dinosaur. Besides this, some pieces, namely, the back part of a skull and a cervical, showed remarkably *Iguanodon*-like characters, and the same is also true of the pubic bone described by Seeley in 1892 as belonging to *Polacanthus*.

As I intend pointing out further on, and as has also already been done by Seeley, *Polacanthus* was constructed essentially after the *Struthiosaurus* plan, and this is the reason why this *Iguanodon*-like basi-occipital has to be removed from the *Polacanthus* remains.

For the removal of the pubic bone from the genus *Polacanthus*, similar arguments can be brought forward.

(1) The ischium and pubis are two closely correlated bones, and as the ischium of *Polacanthus* is totally different from that of *Iguanodon* the same was to be expected as to the pubis.

(2) Both ischium and pubis are correlated with locomotion, and as *Iguanodon* was a bipedal and *Polacanthus*, on the contrary, a quadrapedal animal, we again cannot expect *Polacanthus* to have an *Iguanodon*-like pubis.

Since the so-called *Polacanthus* pubis differs from *Iguanodon* only by being somewhat shorter,[2] and agrees very well with the *Iguanodon*-like basis cranii and cervical vertebræ, I think it may quite well belong to an *Iguanodon*-like animal, and not to *Polacanthus*.

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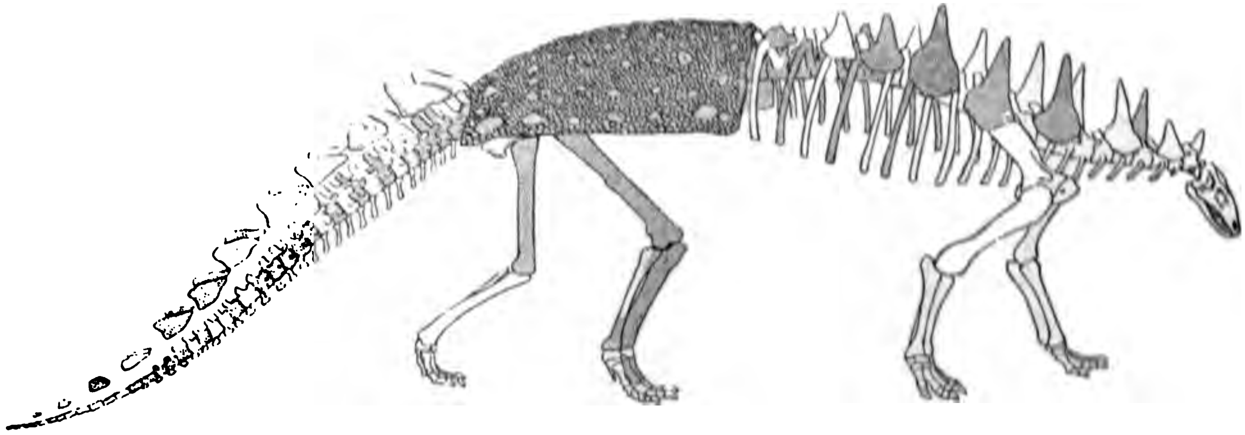
[1] For *Hypsilophodon*, see GEOL. MAG., May, 1905, pp. 203–208.

[2] Even this *may* be due to fracture.



Reconstruction of the skeleton and bony dermal armour of *Polacanthus Foxi* Hulke.

After these preliminary remarks one can determine as belonging to *Polacanthus*—

4 free dorsal vertebræ,
11 co-ossified vertebræ, forming together with ribs and dermal armour the lumbosacral shield,
19 caudal vertebræ,
7 right } ribs,
3 left }
2 femora,
1 right tibia with fragment of fibula,
1 right (?) metatarsal bone,
3 left } dorsal spines,
5 right }
8 left } upper caudal plates,
6 right }
some plates of uncertain position,

and besides these numerous fragments. Comparing these data with those given by Fox, one remarks that only some metatarsals, phalanges, and dermal spines are missing.

Vertebræ.

Although the vertebræ have been described by Hulke, still I think some characters have not been clearly brought out; moreover, a comparison between the vertebræ of *Polacanthus* and other Dinosaurs is still entirely wanting. To Hulke's description of the foremost dorsal vertebræ scarcely anything has to be added, except the facts that the fractured surface of the spinous process shows a quadrate outline, that the neural canal shows lateral compression, that the præ- and postzygapophyses are remarkably near the median line of the body, and that the postzygapophyses project rather far backwards.

Taking into consideration that only 4 free dorsal vertebræ are present, while one can count not less than 7 ribs belonging to the right side, and that between the first and second of these ribs a considerable difference is observable, it is obvious that *Polacanthus* possessed at least 8 free dorsal vertebræ, so that together with the 5 anchylosed lumbodorsal vertebræ the back of *Polacanthus* consisted of at least 13 vertebræ, and assuming the presence of at least 7 cervical vertebræ, this accords well with the number of vertebræ in *Scelidosaurus* (22), while in the reconstruction of *Stegosaurus* 24 vertebræ are given. In *Triceratops* still more vertebræ seem to have been present. At all events the back of *Polacanthus* must have attained a length of 90–100 cm. This dimension will prove of great value in the reconstruction of the dermal armour.

Compared with other Dinosaurs it is, as already mentioned, *Struthiosaurus* to which the dorsal vertebræ of *Polacanthus* show the most remarkable resemblance, and this is the reason why near Fig. 1, representing a dorsal vertebra of *Polacanthus*, a sketch of a *Struthiosaurus* vertebra is also given. There seems, furthermore, some affinity to exist with the vertebræ of *Omosaurus*, while there are no points of resemblance between our animal and the North

American *Triceratops*, the vertebræ of the latter being much more abbreviated and transversely expanded. The dorsal vertebræ of the highly interesting *Stegoceras* and *Stereocephalus* are yet practically unknown.

Compared with *Scelidosaurus* and *Stegosaurus* there exists a remarkable difference, for in the former the diapophyses are given off at a much lower point than in *Polacanthus*, while *Stegosaurus* seems to exaggerate this elevation of the diapophyses which separates *Polacanthus* from *Scelidosaurus*. In a future paper on *Dacentrurus* I intend to come back once more to this question, and I shall try to show why this elevation of the neural arch (visible also in fossil South American sloths) was developed. Here I only wish to draw attention to the fact that in a recent paper (Ann. Mag. Nat. Hist., 1904) Professor Seeley tries to explain this elevation by the upward pressure of the lungs against the neural spines. The anchylosis of the lumbar vertebræ, a unique feature among Dinosaurs, strongly reminds one of the same character in *Glyptodon*, and may be explained as subserving the very same purpose. Hulke's description is equally satisfactory for the sacral as for the lumbar region of the body. The inter-vertebral position of all sacral ribs is, however, a fact worth while mentioning once more.

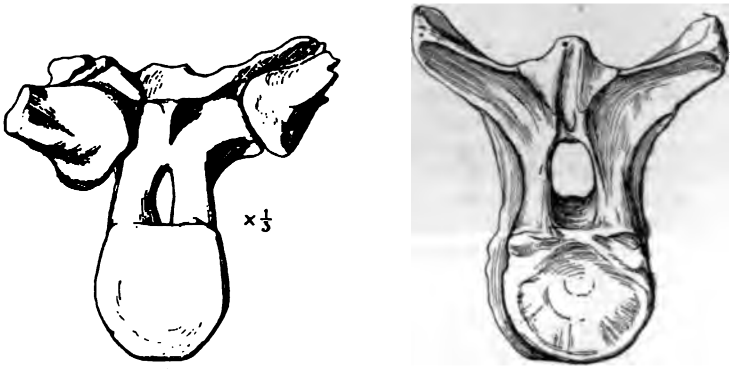


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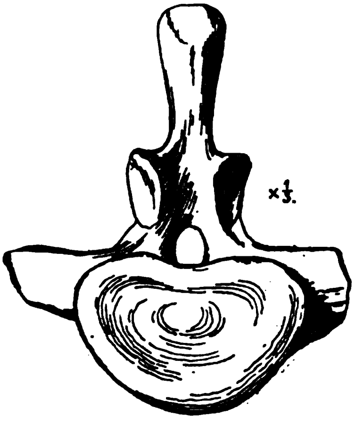
Fig. 1.—Dorsal vertebra of *Polacanthus*, posterior view.
,, 2.—Dorsal vertebra of *Struthiosaurus*, posterior view.

There does not seem to exist any especial widening out of the neural canal in the sacral region, as recorded for *Stegoceras*, and also visible in *Dacenturus* (*Omosaurus*).

Concerning the caudal vertebræ, there is, first of all, the curious fact to be noted, that while Fox originally mentioned 20 vertebræ and I myself managed to count 19 distinct centra Hulke mentions only 13, so that for some time 6 were apparently missing.

As Hulke points out, the proximal caudal (Fig. 3) are much broader than high, and have, in consequence of the neural canal being partly lodged in the centrum, a somewhat depressed heart-shaped outline. At the same time they are much shorter than the dorsals and lumbars, and in consequence have an abbreviated appearance. The processus transversi are given off from the centrum, and are pointed nearly horizontally outwards. A similar abbreviated and expanded structure of the centrum may be observed on some, not yet described, *Dacenturus*-like vertebræ in the Havre Museum. I therefore think the original shape of the proximal caudals in *Polacanthus* has been only slightly disfigured by pressure. The neural spine is not very long, but very thick, and the præ- and low præ- and postzygapophyses do not project far out over the articular surfaces of the centrum.

The median caudals differ by having a less depressed, less expanded, and more elongate centrum, and the diapophyses directed downwards and outwards. The neural canal is much smaller, the chevron bone articulated nearly entirely with the hind part of the centrum, there being scarcely any impression for its articulation on the anterior margins.



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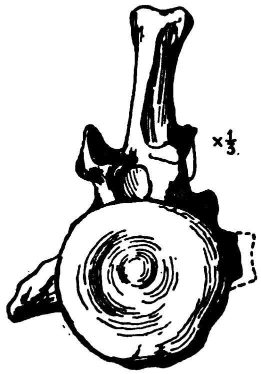

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FIG. 3.—Proximal caudal of *Polacanthus*, posterior view.
,, 4.—Middle caudal of *Polacanthus*, anterior view.

Further back, towards the end of the tail, the vertebræ become still more elongate, and the front articular surface, which was slightly concave in the anterior and median caudals, becomes decidedly convex. The posterior surface remains concave throughout the whole vertebral column. In Figs. 4 and 5 sketches of middle and posterior caudals are given.

Until now only one chevron bone of *Polacanthus* has been detected, but this one is quite characteristic. The top view shows a nearly quadratic section, and at its distal end its thickness is about twice that of its antero-posterior dimensions. Both rami are exceedingly strong, and in accordance with the general massive structure of the tail.

There is a striking resemblance between the root of the tail of *Polacanthus* and that of the gigantic *Megatherium*; the rest of the tail has, however, been reconstructed after the *Hylæosaurus* pattern.

Femur.

The femur of *Polacanthus* differs by its proximal and distal expansion very markedly from the same bone in *Dacenturus*, *Stegosaurus*, or even, though less so, from *Scelidosaurus*, and can only be compared with *Struthiosaurus* from the Gosau formation. Among mammalia it is not with the Proboscidea that the *Polacanthus* femur should be compared, but rather with *Dinoceras*, and this is of no small interest, since it is the Proboscidean femur that the femur of the Stegosaurians and Sauropoda seems to have imitated. In my forthcoming *Dacenturus* paper I intend to ventilate also this question which, to a certain extent, has already been noticed by the late Professor Hatcher.

Dermal Armour.

As Hulke mentioned in 1881 and 1887, one can distinguish in the dermal armour of *Polacanthus* flat plates which are united by synostosis and form a buckler covering the sacrum and the lumbar region; besides, there are small button-like round scutes which, as in *Hylaeosaurus*, belong to the end of the tail; then there are keeled high roof-like scutes which also belong to the caudal region, further on heavy spines rising from a flat triangular base, and besides this large oval plates which show a rounded keel near the middle. It can be seen that in this particular the dorsal ossifications of an animal show a great amount of specialisation.

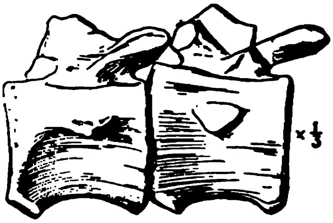

FIG. 5.—Two of the posterior caudals of *Polacanthus*, side view.

The sacrolumbar buckler is well known, being figured and described by Hulke in a supplementary note in 1887. It is to be noticed that the anterior margin is thinned out, thus indicating that the abrupt anterior end is not due to fracture.

Some other points have, however, till now entirely escaped attention. In Hulke's figure in 1887, plate 9, the last lumbar ribs are drawn as if a thinning out towards the margin were to be expected. This is, as an inspection showed, and as Seeley already pointed out in his sketch of the *Polacanthus* pelvis, not the case, but the ribs terminate nearly at the median dorsal margin of the ilium, or are extended somewhat beyond and above the præacetabular process of the ilium. As Professor Seeley has already pointed out, the structure of the ilium bears a remarkable resemblance to the same part in *Omosaurus* and *Stegosaurus*, but I do not think it is dessication, as Seeley modestly puts it, to which we owe since 1892 the visibility of the iliac bone in *Polacanthus*, but I rather think we owe this simply to the Professor's keen eye and intimate knowledge of Dinosaurian structure. Until now, however, though already mentioned and figured by Hulke, no attention has been paid to the fact that across all the dorsal and sacral ribs ossified tendons (ligaments ossified) extend which show a considerable amount of disturbance, and thus clearly prove that they have not been co-ossified either with the superimposed dorsal armour or with the underlying ribs. This alone shows, apart from all other physiological considerations, that right and left from the median dorsal line the dorsal armour was not co-ossified with the ribs, and if co-ossification did occur it could only have happened on the surface of the ilia and along the summits of the neural spines. Through this indication there appears to exist a still greater resemblance between the so-called '*Danubiosaurus*' bone of Gosau and *Polacanthus*, because also in that one a median empty space seems to have separated the underlying rib-like bone. As Professor Seeley has likewise mentioned, the iliac bone extends laterally somewhat beyond the lumbosacral shield.

Besides the dorsolumbar shield Hulke distinguished in his second *Polacanthus* paper three types of dermal armour. The roof-like plates Hulke supposed to be situated *à cheval* above and below the hæmal and neural spines, while the spines were believed to be situated somewhere on the thoracic region, and flat shields are supposed, according to Fox's interpretation, to have covered the belly.

Since the dermal covering of no Stegosaurid animal is yet perfectly known, and the figure Marsh gives of *Scelidosaurus* does not seem quite correct in this regard, it seems at first rather difficult to decide these questions, but having been able to investigate, besides *Polacanthus*, both *Hylæosaurus* and *Scelidosaurus*, and having fitted in *Polacanthus* numerous new pieces together, I am able to assert that the roof-shaped scutes formed two rows right and left of the neural spines of the caudal vertebræ, and that the highest spines belong to the scapular region.

Before dealing, however, with this problematical armour it is necessary to consider first the nearly perfectly preserved mail of *Scelidosaurus*. On the body of *Scelidosaurus* one can trace out quite distinctly seven rows of dermal ossifications, which show that the back of this animal was covered by a median row of keeled scutes, on the sides of which a smaller row is visible. In this second row the tubercles increase the nearer we approach the sacrum. Laterally of this second row we can distinguish on each side two rows of scutes converging forwards, in each of which the scutes gradually augment in height the more they approach the scapular region, so that meeting at the scapula these two rows at last form only one row of rather tall spine-like ossifications. A good idea of the way they augment in height towards the scapula is given in the otherwise not quite correct reconstruction of *Scelidosaurus* published in the edition of the popular guidebook of the British Museum.

In the sacral region of *Scelidosaurus* the dermal ossifications are strongly displaced, and it is only in the caudal region that we find them comparatively in order.

On the middle part of the tail one can clearly distinguish three roof-like plates, one placed on each diapophysis of the centrum and one on the neurapophysis of the arch. Further back one can only observe two roof-like, somewhat asymmetrical plates placed laterally of the neurapophysis and above the diapophysis, thus allowing space for the musculus lateralis caudæ. A thicker plate is visible in one place laterally of the chevron bone. In *Diracodon*, *Stegosaurus*, and *Dacenturus* (*Omosaurus*) we know that the end of the tail was protected by a double row of spines, while the anterior caudals and all the other vertebræ supported one median row of high plates, which in consequence of their abrupt posterior margin were pointed somewhat backwards and formed an acute dorsal ridge.

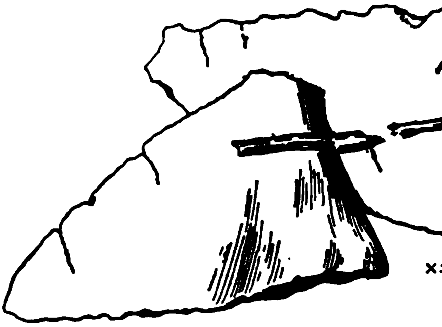

FIG. 6.—One pair of dermal caudal plates of *Polacanthus* (preserved united in matrix), side view.

The probably complex armour of the Ceratopsidæ is altogether unknown, and the same is true for *Acanthopholis* and *Struthiosaurus*. Besides *Scelidosaurus*, *Hylæosaurus* is the only European armoured Orthopodous Dinosaur in which the armour is still partly *in situ*, and though somewhat disturbed, one can notice that this Dinosaur possessed at least two rows of lofty spines which, beginning directly behind the head, increase rapidly in height and attain their maximum development and sharpness in the scapular region. This reminds one to a certain degree of the armour of the Iguana tuberculata. The lumbar region of *Hylæosaurus* is nearly unknown, and in the tail only button-like ossifications seem present.

Turning back to *Polacanthus*, the piece figured by Hulke and fragments which I succeeded in uniting prove that some of the roof-like plates and button-like pieces belong to the armour of the tail. By placing all the roof-like plates in one row beside the caudal vertebræ it soon, however, became evident that this was *not* their natural position, for the row they formed in this way is just about twice as long as the entire series of caudal vertebræ.

This circumstance drew my attention to numerous facts not yet mentioned. Two such caudal spines measure each 21 cm., two others 19, and so on. Besides this the peculiar features of the two largest, the two next, and so on, is always similar, so that arranging the spines according to the colour and size we get a series attaining the presumed length of the tail of *Polacanthus*. This alone would be enough to prove that the plate-like scutes were arranged in pairs along the tail, but besides this and the comparison with *Scelidosaurus* there is yet another point to prove it.

By carefully uniting some fragments I managed to bring two plates of equal size still united with matrix in close contact with an underlying vertebra, and this piece, as well as the unsymmetrical character of two uncrushed pieces (which prove to be the before-mentioned last pair of scutes), shows that the roof-like plates could not have been arranged in any other manner than indicated in the reconstruction. Thus the whole top of the tail of *Polacanthus* was covered with two rows of diverging, broad, sharp-edged plates, while the button-like ossicles were distributed between them so as to cover the empty spaces.

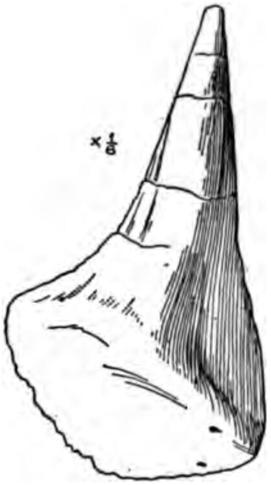

Fig. 7.—Anterior dorsal dermal spine of *Polacanthus*, interior (median) view.

In consequence of their great antero-posterior length each of the main scutes was not fixed merely on one but on two or three caudal vertebræ, thus restricting, together with the ossified tendons, the movement of the powerful tail.

Having finished with the tail and its armour, the question where to place the dermal spines (Fig. 7) of *Polacanthus* became quite easy. They could neither belong to the tail nor to the lumbosacral region. They come, therefore, evidently from the anterior part of the body. They are asymmetrical; according to their size they can be arranged in pairs, and the rows thus formed attain a length of 150 cm. Ribs and free dorsal vertebræ show that the thoracic

region of *Polacanthus* measured 90–100 cm., and is thus considerably shorter than the space which these spine-like ossifications cover. Supposing, however, that the spines extended anteriorly right to the back of the skull, as they do in *Hylæosaurus*, and at least 7–8 cervical vertebræ to have been present, this agrees with the length indicated by the double row of spines, and in consequence one cannot help rebuilding *Polacanthus* in a *Hylæosaurus*-like manner.

The coexistence of large, asymmetrical, round, thick, feebly keeled plates, together with the spines in question, shows furthermore that the other, probably more inferior rows of the dermal covering were not formed by spines, but by elements of another type; these are the single pieces that one cannot place *in situ*.

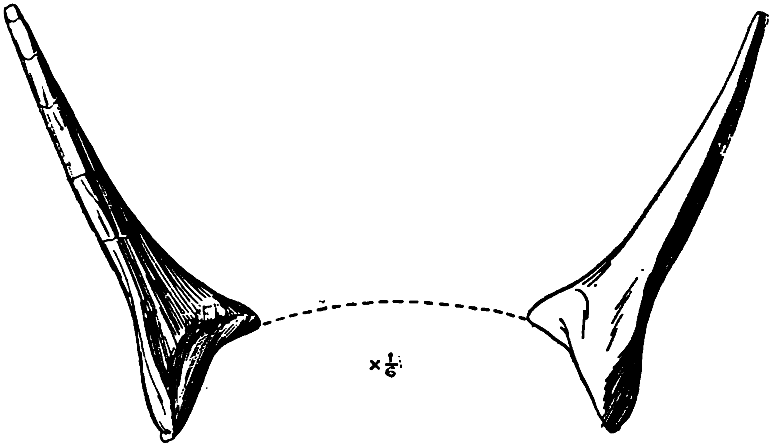

FIG. 8.—Posterior view of a pair of anterior dorsal dermal spines of *Polacanthus*.

Conclusion.

The conclusions drawn from the fresh study of *Polacanthus* are expressed in the reconstruction of the animal as carried out by the 'mason formatori' of the British Museum, Mr. Barlow, under Dr. A. S. Woodward's and my superintendence; and this reconstruction afforded the basis for the Plate accompanying this paper. Through this reconstruction Dr. Hulke's and the Rev. W. Fox's general views about *Polacanthus* are nearly completely in accord. *Polacanthus* was an animal of low stature, whose height at the rump did not exceed three feet. Its strongly marked bones and their large joints speak of its immense muscular power, whilst the shortness of its limbs and the anchylosis of the lumbar vertebræ, welding the loins and the sacrum into a long inflexible rod, give probability to its having been a slowly moving vegetable-feeder. With these characteristics one might venture to add the remark that *Polacanthus* was a sort of Glyptodon among the Dinosaurs.

EXPLANATION OF THE PAGE-PLATE XII.

The shaded parts of the drawing indicate the parts actually preserved; the rest has been reconstructed according to the evidence afforded by *Struthiosaurus*.

I.—On a Collection of Trilobites from the Upper Cambrian of Shantung, North China.

By Henry Woodward, LL.D., F.R.S., F.G.S.

(*Concluded from the May Number, p.* 215.)

(PLATE XIII.)

CONTINUING the notice of Herr H. Monke's paper on the Trilobite-bearing limestone slabs of Yen-tsy-yai, the author serves:—The very dense and solid, slightly arenaceous lime-ones of Yen-tsy-yai consist of horizontal slabs (from 1–2½ cm. ick) of a dark bluish-grey colour. [p. 109] Whilst showing no aces of fossils in their interior, the limestone slabs are on one side s shown on pl. ix)[1] often completely covered with the remains of rilobite carapaces, besides which are found only isolated very minute ells of Brachiopoda. Between them are here and there irregular, ngthened furrows, which may be the tracks of the Trilobites; on e corresponding opposite parts of the slabs are similarly shaped rmiform protuberances. It follows that the fossiliferous side is be considered as the natural upper part of the slabs. In a certain umber of the slabs either both sides or one only are covered sides by a thin argillaceous stratum, which equally contains, ough less frequently, delicate remains of fossils; in all the other abs the fossils present themselves *en relief* and often rest on a small se of limestone, and therefore convey the impression of having en originally covered by a thin argillaceous stratum, which later was washed away by water.

Where the fossils are covered by the protective argillaceous layer d could be developed by preparation, they are in an excellent ate of preservation; where, however, the argillaceous layer is anting, the fossils are generally much worn and their delicate ulpturing has disappeared. Complete carapaces of Trilobites have t been found; with the exception of a single instance in which ven pleuræ are still united in their original connection, all the rapaces were broken up into single segments; these present emselves mixed together, exhibiting either their superior or in-rior side on the upper surface, and are much broken. This ndition of things makes it, of course, difficult to find out the parts hich belong together; on the other hand, it enables one to study e structure of the carapace in all its details. A close examination vealed the remarkable fact that the remains do not belong solely . 110] to adult specimens, but that every possible degree of age, wn to individuals of microscopic size, are present in about equal mbers. The explanation of this phenomenon may be that the thin argillaceous layers between the single limestone strata correspond to periods during which the conveyance of fine argillaceous sediments produced a widespread turbidity of the water, so that the Trilobites could take advantage of these periods to undergo their ecdysis whilst protected from the eyes of their enemies.

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[1] Our Plate XIII is not copied from Herr H. Monke's beautiful plate, but is taken om *a part* of the fine slab presented to the British Museum by the Rev. Samuel uling, M.A., Ching-chow-fu, Kiao-chow, China, and was evidently obtained from e *very same quarry* which furnished the slabs forwarded to Berlin by Herr rgmeister F. Koerfer, from the Upper Sinic Limestones of Yen-tsy-yai, where considerable trade in these slabs, crowded with remains of Trilobites, appears to be rried on by the Chinese, under the title of 'petrified swallows'!

What besides makes these slabs from Yen-tsy-yai particularly interesting is their surprising agreement with the above-mentioned plate from Peking, as the comparison of our pl. ix with Bergeron's pl. xiii will show; so that the latter might be presumed to come from the same locality (as already mentioned, these slabs are commercial articles in China).[1] However, a closer investigation shows small differences in the fauna, and for this reason I incline to admit that the slab in fact comes "from the mountains north of Peking," where, according to Von Richthofen (op. cit., p. 317), the Sinic strata are abundantly represented in the Nankón chain. There is no doubt that this slab belongs to the same, or approximately the same, geological horizon as those from Yen-tsy-yai. Regarding the other question, whether all the 73 slabs from the latter locality are of the same geological horizon, it may be mentioned here, in anticipation, that almost without exception each of the slabs exhibits representatives of all the species of Trilobites named in the collection, save in the case of some of the rarer forms.

In the memoir by Herr H. Monke, from which we have extracted the foregoing account of the Trilobite-bearing beds of Yen-tsy-yai, the author figures and enumerates the following genera and species, namely:—

1. *Agnostus Koerferi*, gen. et sp. nov., taf. 3, figs. 1–9.
2. *Liostracina Krauseri*, gen. et sp. nov., taf. 3, figs. 10–17.
3. *Teinistion Lansi*, gen. et sp. nov., taf. 4, figs. 1–17.
4. *Teinistion Sodeni*, gen. et sp. nov., taf. 5, figs. 1–4.
5. *Drepanura Premesnili*, Bergeron, taf. 5, figs. 5–19.
6. *Drepanura Ketteleri*, sp. nov., taf. 6, figs. 1–14.
   Embryonal forms, taf. 6, figs. 15–18.
7. *Stephanocare Richthofeni*, gen. et sp. nov., taf. 7, figs. 1–15.
8. [*Stephanocare sinense*, Bergeron (not figured).]
9. *Stephanocare*. sp., taf. 8, figs. 1–4.
   Drepanura Ketteleri (hypostome), figs. 5–6.
   Drepanura Premesnili (hypostome), Bergeron, taf. 8, figs. 7–9.
   Stephanocare Richthofeni (hypostome), taf. 8, figs. 10–11.

Slab (taf. 9). This slab, which agrees most exactly (*even in size*) with that of which a part forms the subject of our Plate XIII, contains abundant representatives of parts of all the species of Trilobites enumerated above, except *Stephanocare sinense* of Bergeron. It measures 245 × 205 mm.

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[1] This seems less surprising when it is borne in mind that the higher classes in China are very great connoisseurs of natural curiosities, which they purchase and cause to be mounted as articles of *bijouterie* and *vertu*. Natural stones of all kinds cut and squared up or cut and polished are sold in the shops of cities in China, often *long distances* from the localities where the specimens were originally obtained. Mr. Crick has referred to this circumstance in connection with the celebrated 'pagoda-stones' (sections of *Orthoceras*), which, being cut into slabs and mounted in frames to form ornamental panels and screens, may now be met with as trade articles in almost any part of China.—H. W.

The slab obtained by the Rev. S. Couling also measures 250 × 205 mm., but the portion photographed and figured only represents about 180 × 112 mm. In order to add to the value of the slab an additional tail of *Drepanura Premesnili*, Bergeron (Fig. 1), has been very carefully inserted by the Chinese lapidary into the slab (see Plate XIII, 3*), though its identity as a species which occurs in this bed from Yen-tsy-yai is vouched for by other pygidia of the same species forming a part of the original slab.

In the form named *Drepanura Ketteleri*, H. Monke (which like *Drepanura Premesnili*, Bergeron, is founded upon detached pygidia and separate and imperfect head-shields, also with elongated cheek-spines), the lateral caudal spines are very much more elongated, and remind one of the very long lateral cheek and caudal spines of *Bathynotus holopyga*, Hall, from the Lower Cambrian (or *Olenellus* zone of Walcott), Western Vermont, North America. [Fauna of the Lower Cambrian, C. D. Walcott, pl. xcv, figs. 1, 1*a*, p. 646.]

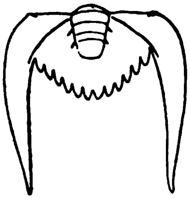

FIG. 1.—Pygidium of *Drepanura Premesnili*, Bergeron. Nat. size. N. Cambrian: Yen-tsy-yai, Province of Shantung, North China.

Stephanocare Richthofeni, of which detached parts are seen upon our slab, Pl. XIII, Figs. 1 and 2, is represented on Herr Monke's plate by six glabellæ, two detached free-cheeks, and three pygidia. There is an element of uncertainty about the correlation of some of these, the underside of the pygidium (figs. 12 and 13) not agreeing very well with the upper side (fig. 11, taf. 7), nor the glabellæ (figs. 1, 2, and 3) with figs. 4, 5, and 6 of the same plate (taf. 7).

I figure, p. 254 (Fig. 2), a detached pygidium preserved on a piece of yellow, compact, fine-grained limestone, which has been polished probably carefully and constantly by hand until it resembles a piece of polished 'soapstone.' It is near to Herr Monke's fig. 11, taf. 7, but either his specimen is unsymmetrical (a very rare occurrence in a Trilobite), or else the artist has drawn the pygidium with six marginal dentations on the left side of the figure and seven on the right, or he intended to indicate that it had one central spine and six marginal spines on each side. In fig. 12, depicting the underside, the artist represents it with six dentations on each side and no central spine. The number of coalesced segments in Herr Monke's fig. 11 is four; in Mr. Couling's specimen, drawn p. 254 (Fig. 2), there are six coalesced segments visible and a small mucro in the centre with six clearly defined marginal serrations on each side. For this form of pygidium Bergeron[1] adopts Meek's generic name *Olenoides*,[2] with which it certainly agrees most closely. I should venture to suggest to Herr Monke that *Stephanocare* should be merged in *Olenoides* (Meek, 1888) as the older and established name.

The specimen here referred to Fig. 2 (locality uncertain, probably from Shantung) measures 31 mm. in breadth, by 19 mm. in length; the axis is 16 mm. broad at the proximal border, where it once joined the cephalothorax, diminishing gradually to 6 mm. above, where it terminates in a slender, rounded, mucronate point, which merges distally into the dentated border. The pleuræ or lateral lobes of the tail are roundly elevated and elegantly curved, as shown in the two views (*a* and *b*, Fig. 2). They are covered with minute rounded pustules. A shallow groove divides each lobe or coalesced segment of the tail by a smooth and well-marked furrow. The divisions of the axis are rounded and raised, and separated by well-defined grooves.

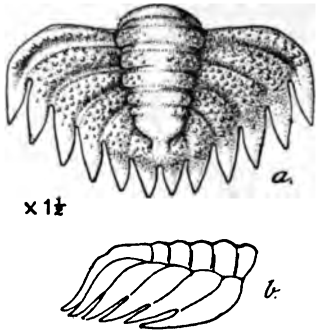

FIG. 2.—*Olenoides Richthofeni?* (Monke), sp. Upper Cambrian (?): Shantung, North China.

It is interesting to notice how closely this form (Fig. 2) agrees with the pygidium of *Olenoides Marcoui*, Whitfield, sp., from the Lower Cambrian of North America (see Walcott, Fauna of Lower Cambrian, pl. xciv, figs. 2*a*, 2*b*, pp. 642 and 575). It also agrees closely with Bergeron's figures and those of Herr Monke's (taf. 7, figs. 11, 12, and 13). Several other pygidia occur on smaller slabs of yellow limestone, obtained by the Rev. S. Couling at Kiao-chow, North China, though not from Yen-tsy-yai, but one of the other fossil-yielding quarries in the Shantung province.[3] There are also some additional Cephalopods which it is hoped may yield further information as to the age of these beds when Mr. G. C. Crick is enabled again to take them up.

It would be very agreeable to review in detail Herr Monke's

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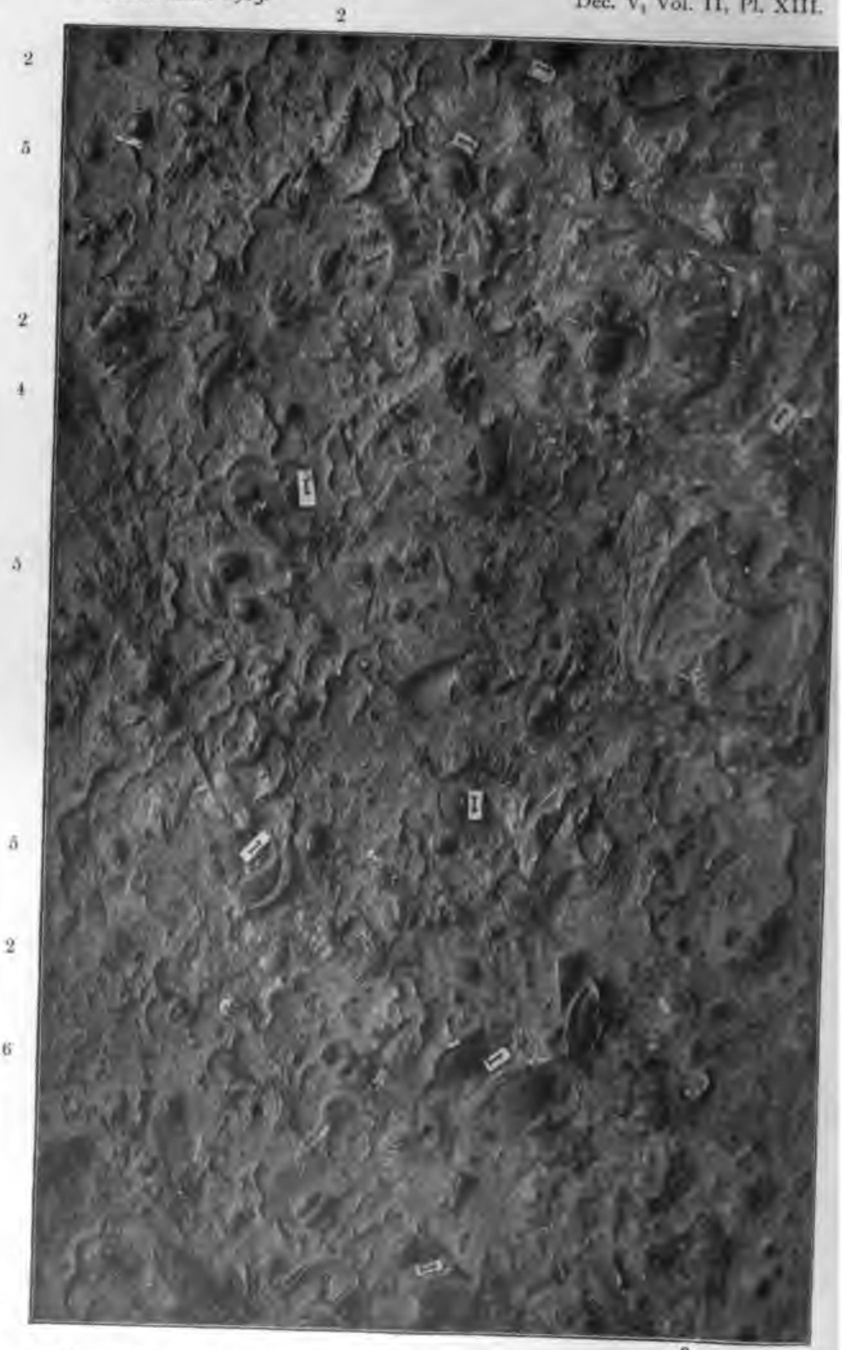
[1] "Etude de quelques Trilobites de Chine": Bull. Soc. Géol. France, sér. III (1899), p. 499, t. 27.

[2] American Journal of Science, ser. III (1888), vol. xxxvi, p. 165.

[3] They are probably identical with Bergeron's *Olenoides Leblanci*, op. cit., p. 506, fig. 5, also seen on slab, pl. xiii, fig. 5.



Slab of Limestone covered with remains of Trilobites of Upper Cambrian age, from Yen-tsy-yai, Shantung, China.

Obtained by the Rev. Samuel Couling, M.A., etc.

species from North China, but I feel before doing so the need of better and more complete specimens at my command upon which to found a revision. I can, therefore, only express my thanks to Herr Monke for the valuable work he has accomplished with the very fragmentary material at his command. I have also to tender my best thanks to the Rev. Samuel Couling for entrusting me with all the specimens he was able to obtain and presenting them to the Geological Department of the British Museum (Natural History), Cromwell Road.

EXPLANATION OF PLATE XIII.

The photo reproduction of fossil remains shown on our plate has been taken from a portion of a large slab procured by the Rev. Samuel Couling, M.A., of Kiao-chow, North China, and in age considered by Herr H. Monke to be Upper Cambrian. The slab and its trilobites agree exactly with a number of others obtained for the Royal Prussian Geological Survey and Berg-Akademie in Berlin from Yen-tsy-yai, in the Province of Shantung, North China. Size of original slab, 250 × 205 mm. Size of portion of slab reproduced in plate, 180 × 112 mm. On the slab may be seen examples of the following genera and species, indicated by small figures on the margin of the plate, and in the case of Fig. 1 on the fossil slab itself:—

Fig. 1.—Free-cheeks of *Stephanocare Richthofeni* (very numerous).
,, 2.—Pygidia of *Stephanocare Richthofeni* (seven examples).
,, 3.—Pygidia of *Drepanura Premesnili*, Berg. (five examples).
,, 4.—Free-cheek with cheek-spine of *Drepanura Ketteleri* (one example).
,, 5.—Head-shields and pygidia of *Agnostus Koerferi* (numerous).
,, 6.—Hypostome of *Stephanocare Richthofeni* (one example).

This slab, together with various other separate Trilobite remains and some Cephalopods, have been presented by the Rev. Samuel Couling, M.A., to the Trustees of the British Museum (Natural History) for the Geological Department.

III.—Note on Fragments of Chert from North China.

By Dr. George J. Hinde, F.R.S., F.G.S.

The fragments of partially weathered chert from North China sent by the Rev. S. Couling,[1] unfortunately without indication of the particular locality or formation where they were collected, are of whitish, slate-grey, or pinkish aspect, and in two instances show traces of banded structure. They consist of cryptocrystalline or microcrystalline silica with small areas in which the silica is of a fibrous chalcedonic character. Remains of organisms can be distinguished in each of the four microscopic sections which have been prepared, but they are generally so shadowy and indefinite that their nature cannot be satisfactorily determined. Some portions of slide marked A are crowded with slender, straight, or slightly curved linear bodies, about ·11 mm. in length by ·01 mm. in width, which in places have a sub-parallel or sheaf-like arrangement. They might be supposed to be sponge spicules, but in their size and disposition they seem to differ from any fossil spicules with which I am acquainted. Slide C largely consists of numerous small, rounded, oval, and conical forms without walls, ranging from ·1 to 1·7 mm. in diameter. In outline and in size many of these bodies might be compared to Radiolaria, but as they are now not sharply delimited from the clear matrix, but by a granular structure without other features, it would be rash to assert, save upon further evidence, that they belong to these organisms. In slide D there are some well-defined circular bodies, ·03 to ·1 mm. in diameter, with clear solid walls, and not infrequently a central spot in each, which very much resemble transverse sections of sponge spicules, and it is possible that this may be their true nature, but some doubt rests on this owing to the apparent absence in the slide of longitudinal sections of spicules.

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[1] Of Ching-chow-fu, Kiao-chow, Shantung, North China.

Though these fragments give fair evidence of a probably organic origin of the chert, it would need carefully chosen specimens of the rock to furnish proof of the nature of the organisms in it.

IV.—On a Displaced Mass of Chalk on the Foreshore of Speeton Cliffs, Flamborough Head.

By B. Hobson, M.Sc., F.G.S.

WHEN revisiting Speeton on the 6th of April, 1905, I was surprised to find that the exposures of Red (Hunstanton) Chalk on the beach at the locality (about 500 yards east of the mouth of Speeton Beck) where the excellent vertical section described by Mr. W. Hill[1] occurs were almost invisible owing to the accumulation of boulders of white chalk by which they were covered. At length I found a small exposure of Red Chalk near low water mark and, within 3 or 4 yards to north of it, that is, seawards, I came across a reef of chalk in well-defined beds, each perhaps 6 or 8 inches thick, weathered to a brownish or drab tint. This chalk, when freshly fractured, was hard and white, quite unlike the true Red Chalk, although practically at the same level. The prevailing dip of the white chalk of the reef was from 25° to 28° to W. 40° S. mg. (= W. 57° S. true), and the length of the exposure along the strike, so far as the limited time at my disposal would allow me to observe, was 65 paces (say 55 yards), the width in the direction of dip being 16 paces (say 13½ yards). So far as I have been able to gather, this reef of white chalk to seaward of, and *apparently* dipping beneath, the Red Chalk has not been described. Four possible explanations of its occurrence may be suggested.

(1) It might be regarded as underlying or forming the base of the Red Chalk. Against this view, the totally different character of the white chalk of the reef from that of the true Red Chalk, and the well-known fact described by Meyer[2] and Lamplugh[3] that the Red Chalk directly overlies Speeton Clay, are conclusive evidence.

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[1] W. Hill, "On the Lower Beds of the Upper Cretaceous Series in Lincolnshire and Yorkshire": Quart. Journ. Geol. Soc., vol. xliv (1888), pp. 337 and 345.

[2] C. J. A. Meyer, "Note on the Passage of the Red Chalk of Speeton into an underlying Clay-bed": Geol. Mag., Vol. VI (1869), p. 13.

[3] G. W. Lamplugh, "On the Subdivisions of the Speeton Clay": Quart. Journ. *Geol. Soc.*, vol. xlv (1889), pp. 581, 603, and fig. 8 facing p. 618.

(2) It might be held to be thrown down by a normal fault against the Red Chalk seen 3 or 4 yards to south of it. The only fault shown on the Geological Survey Map, 95 S.E. (published 1881), is one with an east and west strike by which the main mass of the Chalk, north of the village of Speeton, is thrown down on the *south* against the Speeton Clay. Mr. Fox-Strangways[1] remarks: "The unction of the Chalk with the underlying clays is very obscure owards its eastern end; below Speeton and Reighton we have represented the junction by an uncertain line of fault, the principal evidence for which is obtained in the stream running down to the ea below the former village, where there are beds of red and white chalk resting against the thrown up and disturbed Neocomian Clays. There is a great undercliff of Chalk at this point, which much obscures the section, and which might cause the irregularity observed in the beck." Lamplugh[2] remarks: "I think the supposed ndications of a fault may be better explained by an ancient foundering of the chalk escarpment, possibly in pre-Glacial times." No white chalk is shown on the Geological Survey map to the north of the Red Chalk. Though the shore reef described in the present note would be more interesting if due to a fault, or (thirdly) to a thrust-plane, such as that described by Dr. Rowe[3] as occurring west of Kit Pape's Spot (to south-east of the reef), the most probable explanation of the present position of the reef appears to me to be the following:—

(4) At some former time when the vertical Chalk cliff near this spot had not been eroded so far back (southwards), the line of cliff lay almost along the present line of junction between the Red Chalk of the beach and the white chalk of the reef. A slip took place by which the white chalk on the north side of the plane of slip was thrown down against the Red Chalk, and subsequent marine erosion has exposed both on the shore. Such a slip in the existing cliff occurs at Crowe's Shoot, of which Lamplugh[4] writes: "There is a huge slip about midway in the Speeton range known as Crowe's Shoot. At this place a great slice of chalk 150 yards long has moved forward and downward for 50 or 60 feet, but has there been arrested, and has remained without further change for over a generation."

It should be added that the comparatively high angle of dip of the chalk in the shore reef and the inconstancy in its amount and direction favour the explanation above given.

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[1] C. Fox-Strangways, "The Geology of the Oolitic and Cretaceous Rocks South of Scarborough": Geol. Surv. Mem., 1880, p. 38, and 2nd ed., 1904, p. 89.

[2] See p. 256.

[3] Dr. A. W. Rowe, "The Zones of the White Chalk of the English Coast. Part iv: Yorkshire": Proc. Geol. Assoc., vol. xviii (1904), p. 202.

[4] G. W. Lamplugh, "Notes on the White Chalk of Yorkshire": Proc. York Geol. and Polyt. Soc., vol. xiii (1896), pt. 2, p. 175.

V.—ON *STOMATOPORA ANTIQUA*, HAIME, AND ITS RELATED LIASSIC FORMS.

By W. D. LANG, M.A., F.Z.S., F.G.S., of the British Museum (Natural History).

(WITH A FOLDING TABLE I AND PLATE XIV.)

STOMATOPORA ANTIQUA was first described and figured by Haime[1] from specimens occurring on *Gryphæa* in the Lower Lias of France. I have not been able to find any record of an English specimen except that in the Survey memoir on the Lias of England and Wales.[2] But recently several specimens of a *Stomatopora* resembling *S. antiqua*, Haime, were found in the collection of the late Mr. R. F. Tomes. The fact that all the specimens were encrusting *Gryphæa* is remarkable; for though many hundred specimens of various molluscs from the Lower Lias were searched, and of these all sorts of oysters with especial care *Gryphæa* was the only form encrusted by *Stomatopora*.

In the British Museum catalogue[3] *S. antiqua*, Haime, is made a synonym of *S. dichotoma* (Lamouroux),[4] a Bradfordian form. But an examination of the material alluded to, of which more than a dozen zoaria were sufficiently well preserved to admit of measurements of portions of them after the method described in a former number,[5] has shown not only that this form is a distinct species, but that it exhibits features which make it probable that it is more primitive than any other Jurassic *Stomatopora* as yet described. Even Gregory included it with some hesitation in *S. dichotoma*, for in writing of that species he says[6]: "The one [form] in regard to which I feel most doubt is *S. antiqua*, Haime, from the Lower Lias. Haime founded this practically only on variations in the branching of the lines of the zoœcia. This character is shown by the large series of specimens in the British Museum collection to be of little value. The peristomes are not so much raised as in the typical form, but in this character likewise there are such variations in the same zoarium that the difference is not sufficiently well marked." The systematic value of the two characters mentioned has been discussed in the paper[7] just quoted, in which the author attempts to show that the branching is of paramount importance.

It seems advisable, having the material in hand, to define the species with greater exactness, revising Haime's definition, and by investigating the stages of growth to gain some idea of its relations to other forms.

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[1] J. Haime, "Description des Bryozoaires Fossiles de la formation Jurassique": Mémoires de la Société Géologique de France, ser. II, vol. V (1854), pp. 162–163.

[2] H. B. Woodward: "The Lias of England and Wales," 1893, p. 365.

[3] J. W. Gregory: British Museum Catalogue of Jurassic Bryozoa, 1896, p. 44.

[4] J. Lamouroux: "Exposition Méthodique des genres de l'ordre des Polypiers," 1821, p. 84, pl. lxxxi, figs. 12–14.

[5] W. D. Lang, "The Jurassic Forms of *Stomatopora* and *Proboscina*": GEOL. MAG., Dec. V, Vol. I (1904), p. 315.

[6] J. W. Gregory: loc. cit., p. 48.

[7] W. D. Lang: loc. cit., pp. 318–322.

It is to facilitate the comprehension of the method of investigation employed that the reader is referred to the paper on "The Jurassic Forms of *Stomatopora* and *Proboscina*."[1] In this paper great prominence was given to the mode of branching; and it was pointed out that the remarkable regularity of this character was peculiar to the Jurassic forms. Three types of branching were described as Type I, the Intermediate type, and Type II; and the order of succession was invariable, the first passing gradually into the second, and the second into the third type. If it may be inferred from the irregularity of the branching in the few Silurian specimens of *Stomatopora* examined that the pre-Jurassic ancestors of the species under consideration were irregular in their mode of branching, the Jurassic regularity appears in the Lower Lias form as a new character superimposed upon a pre-Jurassic irregularity. The apparent expression of this is that although in the Lower Lias form the regular dichotomous branching after Type I, the Intermediate type, and Type II may be observed, it is somewhat obscured by a slight irregularity, and the daughter zoœcia at each dichotomy are of unequal length. Thus a second character becomes involved—the proportion of the length of the zoœcium to the breadth. These points are illustrated in Pl. XIV, Figs. 4 and 5.

Moreover, a slight irregularity occurs in a third character—the shape of the zoœcium. In the Oolitic forms primitive cylindrical zoœcia become pyriform, and in more specialized forms often revert to a cylindrical shape. In *Stomatopora antiqua*, Haime, though the general sequence is cylindrical—very slightly pyriform—cylindrical by far the greater part of the zoarium having cylindrical zoœcia, occasionally a comparatively pyriform zoœcium occurs without any relation to the general sequence in shape. This is well shown in Terquem & Piette's figure of *S. antiqua*, Haime,[2] and in the specimen B.M. D. 7623 (Pl. XIV, Fig. 5). It is true that such sporadic irregularity in any one character is liable to occur to some extent among the most regular Jurassic forms. And the explanation is suggested that so plastic and undifferentiated are these primitive forms that rigid stability of character is not to be expected in the same degree as in the case of the ornamentation of such a highly specialized group as the Ammonites.

Mr. Buckman has offered another explanation of the sporadic appearance of the comparatively pyriform zoœcia. Jackson[3] has shown that in plants a new branch tends to recapitulate former characters more primitive than those peculiar to that part of the plant whence it springs. He applies this to animals as well as to plants, and voices it in the law that "throughout the life of the individual, stages may be found in localised parts, which are similar to stages found in the young, and the equivalents of which are to be sought in the adults of ancestral groups."

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[1] W. D. Lang: loc. cit.

[2] O. Terquem et E. Piette, "Le Lias inférieur de l'est de la France": Mém. Soc. Géol. France, ser. II, vol. viii (1868), p. 124, pl. xiv, fig. 32.

[3] R. T. Jackson, "Localised Stages in Development": Mem. Boston Soc. Nat. Hist., vol. v, No. 4 (1899), p. 92; see also pp. 139, 141.

Applying this principle, we may say that at every branch i a colonial form such as we are considering there is a potentia recapitulation. Now the slight tendency to pyriformation a dichotomies 1 and 2 in the present form shows that the genera cylindrical stage was preceded by one which was more or les pyriform. The tendency, then, at each dichotomy is to recapitulat this stage. The potential recapitulation occasionally becomes actua and appears as the sporadic production of somewhat pyriform zoœci

A third explanation of these sporadic zoœcia is that they a simply gonœcia. And the fact that in all organisms reproducti tissue arises from undifferentiated cells may furnish a hint as t why primitive characters are shown in reproductive zoœcia.

Having indicated the directions in which difficulties may b expected in applying the scheme of measurement advanced in th former paper, it is possible to limit Haime's species by the followin definition, which takes into account stages of growth :—

I. STOMATOPORA ANTIQUA, HAIME. (Pl. XIV, Figs. 2, 4, 5, and 7.

Characters.—Zoarium loose and spreading, the first dichotom being after Type I at an angle of about 180°. The Intermediat type of branching appears at the third or fourth dichotomy, an Type II by the fifth or sixth. As has already been remarked, th branching is often somewhat irregular, so that the exact type is har to determine. There are two peristomes before the first dichotom and generally one between the first and second. The acme reached with three or four peristomes between the third and sixt dichotomies; after which, with a small check at about dichotom 7, the number of peristomes between each dichotomy rapidl diminishes. The proportion of the length of the zoœcium to th breadth is very variable, but by examination of a number o specimens a general sequence can be recognised. That of th protœcium is about 1, of the second zoœcium about 2. The acm of length is at dichotomies 1 and 2, where it is from 2 to 2½ From dichotomy 2 it gradually diminishes until it is only 1½ a dichotomy 9. The shape of the zoœcia is irregularly cylindrical with a slight tendency to pyriformation between dichotomies 1 and 2 and with an occasional irregular pyriform zoœcium as alread noticed. The ornamentation is a very slight, fairly fine ribbing, bu the zoœcia often appear smooth, owing to bad preservation, fo which reason it is hard to see any regular change in this characte during the growth of the colony. The sides of the zoarium tend t be flattened on to the object which it encrusts.

For comparison the original description by Haime is her given[1] :—

“Les mailles de ce testier ont une tendance à se rapprocher de l forme d'une rhombe irrégularier, et dont les angles seraient émoussés Les sept premières testules produisent deux bourgeons; il arriv fréquemment que deux testules jumelles soient un peu inégales e grosseur, et restent presque complétement accolées l'une à l'autre

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[1] J. Haime: loc. cit., pp. 162-163.

i. 6
i. 9
…
…
…
…

2
1
1–2
1–3
1
…
…
…
…

1
1½
2
2–2½
2
2–2½
2
…
…
…
…

cyl.,
casionally
s.pyr.

v.s.r.

ividus auxquels elles donnent naissance s'écartent l'un de l'autre. Entre une bifurcation et celle qui la pte ordinairement deux ou trois péristomes en série. La nte des testules est médiocrement allongée, légèrement 'origine, puis cylindroide et faiblement aplatie; elle plis fins et d'autres plus prononcés; les pores sont ez écartés. La grande largeur des testules dépasse un llemétre.

rappelle tout à fait par son aspect général la *S. dichotoma*; gularités que nous venons d'indiquer dans le mode de n, ainsi que la forme légèrement conique des testules, ent suffisamment. Ces testules sont d'un autre côté ins longues et moins lisses que dans la *S. Waltoni*.

exemplaires que j'ai observés étaient fixés sur Gryphées nt été découverts par M. Terquem dans le lias inférieur Moselle)."

seen that Haime expressly indicates "les irrégularités le de multiplication"—the pre-Jurassic trait of this o that branching after Type II is exhibited, the es jumelles . . . . restent presque complétement e à l'autre." But the most important fact is not given, point in the life-history of the colony when Type II pearance.

ng table (Table I)[1] of observations on nineteen zoaria me idea of the limits of variation in this species. The the first column are those of the dichotomies at which the is taken, starting at the proximal end. The columns are e letters B.M. D., followed by two numbers. The letters number stand for the British Museum register number men, the second number for that of the zoarium on that In the first eight examples the first dichotomy was seen, ers of the dichotomies are known. In the last eleven, the first eight by a double vertical line, the proximal zoarium was wanting, and so the first dichotomy shown l as x, the second as $x + 1$, etc. But by comparison with t, the value of x was surmised. For an explanation of scheme I can only refer to my former paper.[2] The used in the table are as follows:—

I, II. = branching after Type I, Type II.
i. = branching after the Intermediate type.
s. = slightly.
v. = very.
90°, etc. = branches diverging at an angle of 180°, 90°, etc.
cyl. = cylindrical.
pyr. = pyriform.
sm. = smooth.
r. = ribbed.

's figure the zoœcia are as a whole shorter than in the imens, but there is very little difference; and, as has shown, partly owing to the irregular branching, the considerably.

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ble I *to be inserted to face* this page.

[2] W. D. Lang: loc. cit.

Synonymy.—The only figured forms which are likely to l confounded with this species are those described from the Low Lias of France by Terquem & Piette[1]; and it may be incidental remarked here that the form mentioned as having been recorded the Survey memoir is written "*Stomatopora antiqua*, Terquem Piette." Unfortunately there is some confusion in the Fren authors' paper. Two forms are recorded—*S. antiqua*, Haime, a *S. Haimei*, Terquem & Piette. The latter species is described a figured. The former is not described, but Haime's description referred to, and two figures are given on Pl. XIV. The figures which the direction of the text refers are obviously wrong, bei representations of *Neuropora*. However, the legend beneath the pla makes it clear which figures are meant. But the larger of the (the other being a life-size representation of the whole zoariu is a reproduction, with rather larger peristomes and rather stout zooecia, of Haime's figure of *S. antiqua*. It looks, therefore, as Terquem & Piette had meant the figures they have call *S. antiqua*, Haime, to apply to their new species *Haimei*. As stands, their *S. Haimei* must become a synonym of *S. antiq* Haime, unless or until the form represented by their figure c be proved to differ from Haime's *S. antiqua*. It is a great pity th the name *Haimei* should have to be dropped; for no one who h used this author's beautifully executed plates of these forms cou wish otherwise than that his name should be associated wi this genus.

The form recorded as *S. antiqua*, Haime, is described below *S. Gregoryi*, sp. nov.

Horizon and locality.—Haime records the type-specimen from " lias inférieur de Valière (Moselle)."

The English specimens are from the Sinemurian, mostly from be which are at the horizon of the zones of *Deroceras armatum*, *Upton Jamesoni*, and *Amaltheus ibex*, but the exact zone cannot determined.

Specimens B.M. D. 7623 and 7624 are from what is probably t zone of *Uptonia Jamesoni*[2] at Aston Magna, north of Moreton-in-th Marsh, Gloucestershire. From the same locality is a specim B.M. D. 7622, which is labelled "junction of the Middle and Low Lias, Aston Magna."

Specimens B.M. D. 7619 and 7620 are from probably the same zon at Fenny Compton, Warwickshire, north of Banbury, Oxfordshire.

The specimen B.M. D. 7625 is from what is probably the zone *Asteroceras obtusum*[4] at Honeybourne, east of Evesham, Worceste shire.

S. Haimei, Terquem & Piette, is recorded as occurring "Lumachelle ferrugineuse à *B. acutus* de Chilly, sur une val de l'*Ostræa chillyensis*." This horizon is Sinemurian.

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[1] O. Terquem & E. Piette: loc. cit.

[2] H. B. Woodward: loc. cit., p. 155.

[3] H. B. Woodward: loc. cit., p. 161.

[4] H. B. Woodward: loc. cit., p. 154.

II. *Stomatopora antiqua*, Haime, mutation *capricornensis*.

(Pl. XIV, Figs. 1 and 3.)

Fragmentary zoaria of a form hardly distinguishable from the Sinemurian species ***Stomatopora antiqua***, Haime, occur rather commonly encrusting specimens of the coral ***Montlivaltia Victoriæ***, Duncan, from the Middle Lias, zone of ***Liparoceras capricornus***[1] at Cherrington, Warwickshire, north-east of Moreton-in-the-Marsh, Gloucestershire. The only apparent difference between this and the Sinemurian form is in that the branching in the former is far more regular, approaching in this respect the Oolitic species. This point is shown in Diagram I, p. 267, where Fig. 3 represents *S. antiqua*, Haime, and Fig. 4 its mutation in the *capricornus* zone. This being the only difference which the fragmentary and ill-preserved material presents, it looks as though this form was a direct modification of *S. antiqua*, Haime, in time; and since no other form has been found at this horizon resembling more closely the Sinemurian species, it may be looked upon as the modification of *S. antiqua*, Haime, in the higher zone. But because this form is not identical with *S. antiqua*, Haime, it is convenient to have a name whereby to distinguish this mutation, as it is called, and I therefore propose to name it *S. antiqua*, Haime, mutation *capricornensis*, indicating in the name the horizon at which the mutation is found.

A table of observations on these fragments is given below.

TABLE OF OBSERVATIONS ON INDIVIDUALS OF *STOMATOPORA ANTIQUA*, HAIME, MUT. *CAPRICORNENSIS*.

	B.M. D. 7539. $x = 1$.	B.M. D. 7470. 2.	B.M. D.7626.	B.M. D.7628.	B.M. D.7629.
TYPE OF BRANCHING.					
At dichotomy x	I. 140°	? i. 45°	II. 100°	I.45°–60°	i. 60°
,, $x + 1$ ...	i. 90°	II. < 45°	...	i. 90°	i. 60°
,, $x + 2$ ...	I. s.i. 60°–90°	...	...	...	i. 45°
,, $x + 3$ ...					
NUMBER OF PERISTOMES. Between dichotomies					
$x - 1$ and x ...	2	...	2	...	...
x and $x + 1$ ...	1	2	2	2	2
$x + 1$ and $x + 2$ ...	3	...	...	...	2
RATIO OF LENGTH OF ZOŒCIUM TO BREADTH.					
At dichotomy x	2½	1½–2	2–2½	1½–2	2–2½
,, $x + 1$ ...	2	2	...	...	2–2⅓
,, $x + 2$ ...	2	...	...	...	2–2½
,, $x + 3$ ...					
SHAPE OF ZOŒCIUM ...	cyl.	cyl.	cyl.	cyl.	cyl.
ORNAMENTATION ...	?	?	?	?	?

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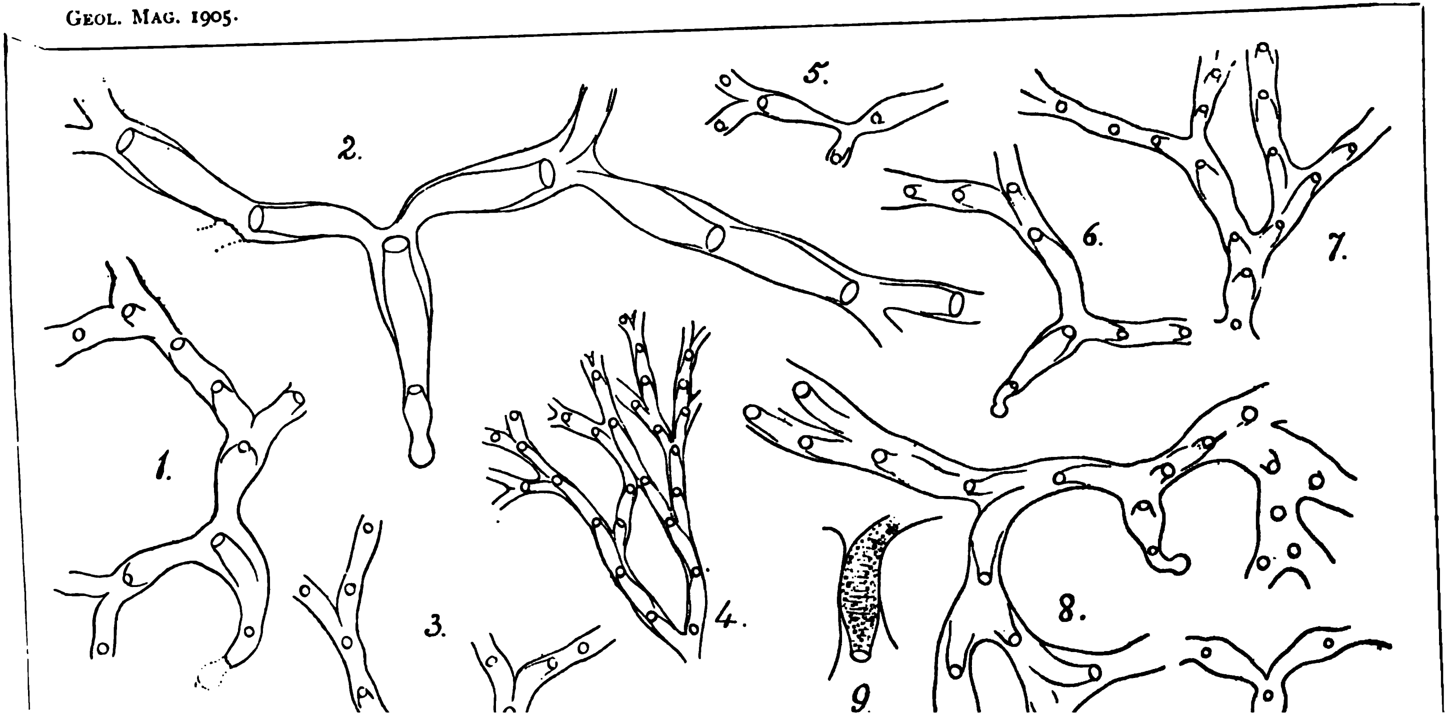
[1] H. B. Woodward: loc. cit., p. 157.


1.
2.
3.
4.
5.
6.
7.
8.
9.

MATOPORA RICHARDSONI, SP. NOV. (Pl. XIV, Figs. 8 and 9.)

imen has been found in the Lias of Toddington, north-east enham, Gloucestershire, by Mr. L. Richardson, F.G.S., its early stages resembles *S. antiqua*, Haime. Branching e II occurs as early as the second or third dichotomy, and l by the fourth, at which point the zoarium has become oid. This early branching after Type II is represented m I, p. 267, Fig. 5, where only the Stomatoporoid stages n, and the branching not carried beyond dichotomy 3, in t an equal comparison may be made with the other forms The irregularity in the branching is retained throughout atoporoid stages, showing this to be a primitive character erived from *S. antiqua*, Haime, and not, as appears to be in certain Oolitic forms, a secondary irregularity following ranching after Type II, and giving rise to such forms as *a morinica* (Sauvage). The tendency of the sides of the to become flattened out on the object encrusted so as to elvage,' as Gregory calls it,[1] is more pronounced than in ı, Haime, and produces in the distal part of the zoarium of *Proboscina* resembling the species above mentioned.

ght pyriformation exhibited by *S. antiqua*, Haime, between es 1 and 2 is absent. The zooecia are cylindrical throughout first dichotomy.

be seen on referring to Pl. XIV, Fig. 8, that after the otomy the right-hand branch is more specialized and Proboscinoid sooner than the left-hand branch. A second on the same specimen exhibits similar characters to that and figured, as far as can be seen through the obscuring

ne in which this specimen was obtained was probably that *a Jamesoni*. At any rate this is the approximate horizon.

more zoaria (specimens B.M. D. 7630) on an example of *tia Victoriæ*, Duncan, in the collection of the late Mr. R. F. rom the zone of *Liparoceras capricornus* at Cherrington, shire, north-east of Moreton-in-the-Marsh, Gloucestershire, the specimen just described sufficiently to be included in es. An outline figure of one of these specimens is given [V, Fig. 6.

on Diagram I represents the specimens from the *capricornus* same form as Fig. 5 being repeated to indicate that that es into the higher zone unchanged.

llowing is a table of changes in the characters of this uring its life-history:—

f Branching.

dichotomy 1	...	Type I at 120°.
,, 2	...	Type I-Intermediate type at 90°–100°.
,, 3	...	Intermediate type-Type II at 60°.
,, 4	...	Type II at < 60°.

iregory: British Museum Catalogue of Cretaceous Bryozoa, vol. i (1899), *Frequency of Branching.*

Number of peristomes before dichotomy 1	2
„ „ between dichotomies 1 and 2	1–2
„ „ „ „ 2 and 3	1–2
„ „ „ „ 3 and 4	1–2

Ratio of Length of Zoœcium to Breadth, the latter being taken as 1.

Before dichotomy 1 { zoœcium 1	2
„ 2	1½
At dichotomy 1	1½–2½
„ 2	2–3
„ 3	2–2½
„ 4	1½–2½

Shape of Zoœcium.

Before dichotomy 1 { zoœcium 1, cylindrical.
„ 2, slightly pyriform.
From dichotomy 1 to dichotomy 4, cylindrical.

Ornamentation. Very slightly ribbed.

IV. *STOMATOPORA GREGORYI*, SP. NOV. (Pl. XIV, Fig. 10.)

Mention was made above to the figures given by Terquem & Piette of *Stomatopora antiqua*, Haime. And though only a small part of the zoarium is drawn large enough to clearly show its characters in detail, it appears, by taking what is to be seen in the larger figure with the loose appearance of the branching in the smaller figure, that this form is more primitive than Haime's type, and does not exhibit branching after the intermediate type so soon, if at all, in its life-history.

Moreover, a specimen (B.M. D. 7470, zoarium 1) from the *capricornus* zone of Cherrington, encrusting *Montlivaltia Victoriæ*, Duncan, shows at its first dichotomy a more marked pyriformation than the specimens of *S. antiqua*, mutation *capricornensis*, and resembles more nearly a specimen (B.M. D. 2131) of *S. dichotomoides* (d'Orbigny). Unfortunately more of the former specimen is not preserved, so it is impossible to say whether its further branches showed the characters of *S. dichotomoides* (d'Orbigny). Now the latter species, an Inferior Oolite form, is more simple in its branching than *S. antiqua*, Haime; nor is there anything to show that this simplicity of branching, which even in the distal dichotomies does not proceed beyond Type I, is not primitive. The form, then, must have had a Liassic ancestor with as simple a type of branching. Terquem & Piette's figures of *S. antiqua*, Haime, supplies a possible ancestor. This form, for which I propose the name *S. Gregoryi*, would only differ from *S. dichotomoides* (d'Orbigny) in the pre-Jurassic irregularity of branching and in the lesser pyriformation of the zoœcia. Since the former character was lost and regular branching was acquired during the Pliensbachian time by *S. antiqua*, Haime, it is quite likely that the specimen mentioned above (B.M. D. 7470, zoarium 1) represents the proximal end of a zoarium in this stage, and the form would be known, according to the system advocated, as *S. Gregoryi*, mutation *capricornensis*. The Sinemurian

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[1] O. Terquem et E. Piette: loc. cit., pl. xiv, fig. 32.

and the Pliensbachian mutation are represented by Figs. 1 and 2 in Diagram I, on this page.

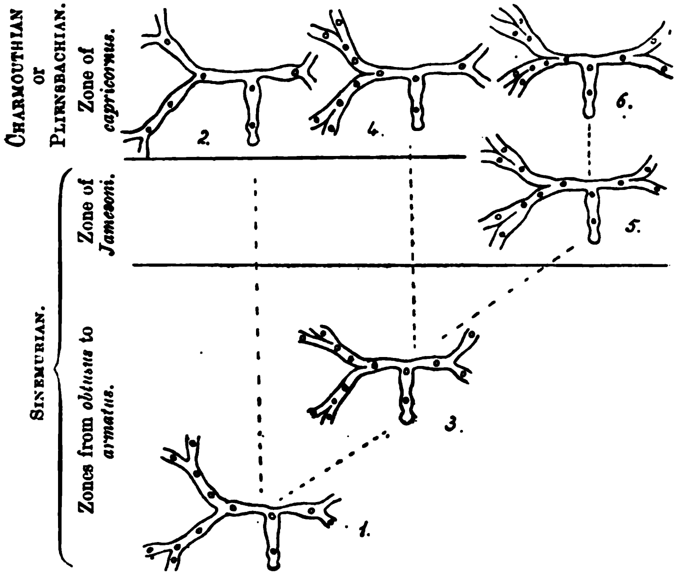

DIAGRAM I.—To show the changes in the method of branching and in the shape of the zoœcium in *Stomatopora antiqua*, Haime, and its related forms.

FIG. 1.—*Stomatopora Gregoryi*, sp. nov.
,, 2.—*Stomatopora Gregoryi*, mut. *capricornensis.*
,, 3.—*Stomatopora antiqua*, Haime.
,, 4.—*Stomatopora antiqua*, Haime, mut. *capricornensis.*
FIGS. 5 and 6.—*Stomatopora Richardsoni*, sp. nov.

Note.—A difficulty arises in the system of nomenclature advocated above, wherein the mutation of a species is named as such as if it were a variety; but with this difference, that, while a variety is named arbitrarily, just as a species, the mutation is named according to the horizon at which it occurs. The difficulty is met when the mutations of a given species pass upwards into a form already named. For suppose in the case above it could be demonstrated that *S. Gregoryi* passed upwards through its mutation *capricornensis* and other possible mutations into the Aalenian species *S. dichotomoides* (d'Orbigny), it might be asked, at what point would the one species end and the other begin. A moment's consideration would show that supposing our knowledge of the evolution of a group of organisms were absolute, we should have a number of species in various ramifying series, each merging imperceptibly backwards into its precursor and forwards into its successor. A further examination would show that the forms designated 'species' were groups of individuals taken at arbitrary points in the evolutionary series. For these points would not have been fixed upon according to any predetermined plan, as, for instance, to mark a period of comparative stability in the evolving form. To have definitely named such evolutionary stations would have implied a complete knowledge of the evolution of the group. But as each point in the series was independently met with, so it was described and named, and its connection with other points discovered later. In the supposed case where this has been done, more than two species would occasionally be found in one unbranched series. It might be said that the names of the middle species, that is, those that lay along one branch between two bifurcations, were useless and might be discarded, or, being only mutations, might be named as such. This, however, would be a pity, for reference marks are needed along an unbroken series. Moreover, since the superfluous names are thus treated as synonyms, the question of priority is at once raised. Therefore it seems advisable in such a case to keep the intermediate names. But where, as in the species described in this paper, slight, hitherto unnamed differences occur as the form passes from zone to zone, the forms could be named as mutations, like those above, in order not unduly to multiply 'species.' The original difficulty, namely, to say where the mutations of one species end and those of another begin, could be solved conventionally by taking the first stratigraphical boundary below the higher species. And if it be objected that such a division is purely conventional, it may be answered that it is chosen no more arbitrarily than is the point in the series from which the individuals comprising a species were taken. With complete knowledge specific boundaries must be conventional. And all the difficulties in nomenclature arise from the inadequacy of the system now in use, which seeks to bind within rigid systematic limits the phases of series which are in a perpetual state of flux.

EXPLANATION OF PLATE XIV, p. 264.

Fig. 1.—D. 7539. *Stomatopora antiqua*, Haime, mut. ***capricornensis***, encrusting *Montlivaltia Victoriæ*, Duncan. Middle Lias: zone of *L. capricornus*, ? Cherrington, Warwickshire. × about 12.

,, 2.—D. 7620, zoarium 2. *Stomatopora antiqua*, Haime, encrusting *Gryphæa*. Lower Lias: about *Jamesoni* zone, Fenny Compton, Warwickshire. × about 28.

,, 3.—D. 7629. *Stomatopora antiqua*, Haime, mut. ***capricornensis***, encrusting *Montlivaltia Victoriæ*, Duncan. Middle Lias: zone of *L. capricornus*, Cherrington, Warwickshire. × about 9.

,, 4.—D. 7620, zoarium 4. Another zoarium on the same specimen as Fig. 2. × about 8.

,, 5.—D. 7623, zoarium 1. *Stomatopora antiqua*, Haime, encrusting *Gryphæa*. Lower Lias: about *Jamesoni* zone, Aston Magna, Worcestershire. × about 11.

,, 6.—D. 7630, zoarium 2. *Stomatopora* (?)***Richardsoni***, sp. nov., encrusting *Montlivaltia Victoriæ*, Duncan. Middle Lias: zone of *L. capricornus*, Cherrington, Warwickshire. × about 15.

,, 7.—D. 7619, zoarium 1. *Stomatopora antiqua*, Haime, encrusting *Gryphæa*. Lower Lias: about *Jamesoni* zone, Fenny Compton, Warwickshire. × about 8.

,, 8.—*Stomatopora Richardsoni*, sp. nov., on a Brachiopod. Lower Lias: about *Uptonia Jamesoni* zone, Toddington, Gloucestershire. × about 15.

,, 9.—Part of the same specimen as Fig. 8. × about 18.

,, 10.—D. 7470, zoarium 1. *Stomatopora* ***Gregoryi***, n.sp., mut. ***capricornensis***, encrusting *Montlivaltia Victoriæ*, Duncan. Middle Lias: zone of *L. capricornus*, Cherrington, Warwickshire. × about 12.

VI.—OLD LAMPS OR NEW? ANOTHER CONTRIBUTION TO DEVONSHIRE CONTROVERSIAL GEOLOGY.

By HARFORD J. LOWE, F.G.S.

UNSOLVED geological problems, or what perhaps may be better described as obscure points in geological history round which conflicting hypotheses have arisen, are to be found in many parts of our Islands, but Devonshire seems to be an usually prolific field for them. Mr. W. H. Hudleston, F.R.S., in his presidential address to the Devonshire Association in 1889, enumerates nine questions propounded by Pengelly in 1868 as still requiring special consideration in the future. Of these possibly three may be said to have nearly or quite got beyond the controversial stage, but in the meantime others have arisen, and it would thus appear that the undecided position of numerous points demanding further investigation is the normal condition of a science in the developmental stage.

Evolution involves occasionally the disuse and reversion of organs which formerly were of service, but the more general mode of progress is by strengthening and more highly developing the essential working parts so as to better fulfil their functions in the more complex organism.

Similarly, in the higher development of a science some early working hypotheses must either be abandoned or modified to meet further discovery and more widely extended correlations. The earlier theory, however, is usually tenacious of the hold it has gained by prior possession, and the newcomer must need not only present credentials that will bear the closest scrutiny, but also possess the irresistible power of simplicity and superior fitness in order to gain the position it lays claim to.

Now there is a time-honoured and simple theory respecting the origin and formation of some peculiar deposits within the basin of the River Teign, whose right to possession of that small holding has been called in question by several statements to be found scattered among the geological records. No direct attempt has been made to oust the old tenant and place another with a better title in its place, but its position has been discredited by casual remarks and innuendo, and its existence has been ignored when its territory has been invaded by the explorer.

We learn from one of our early masters, who is also regarded as one of the keenest and most reliable of observers, De la Beche, that within an area roughly defined as from a little south of Newton Abbot to a little north and east of Bovey Tracey lie deposits of lacustrine origin which now form a tract of level land traversed by the streams Teign and Bovey, which presumably brought down the material now filling up the lake depression formerly occupying this part of their courses. In the master's own words—"From the manner in which the Bovey deposit conforms to the valleys adjoining it, the character of the clays and sands, and the greater purity of the clays towards Kingsteignton and away from the granite of Dartmoor, we may be led to infer that prior to the production of the Bovey beds a depression was formed in this locality subsequently to the destruction of the mass of chalk and a considerable portion of the greensand which there once existed, and that the materials for this deposit were chiefly derived from decomposed parts of the adjoining granite gradually carried down by streams, the quartzose parts forming the sands, the decomposed felspar borne onward to where it could quietly settle and form the clay."[1]

That is the simple explanation given in 1839 to account for the peculiar clay, sand, and lignite beds of the Bovey area, and it has been confirmed and strengthened by other geologists, particularly Pengelly, who investigated the formation fully and from whose palæontological discoveries therein Professor Heer arrived at the conclusion that the beds were of Miocene age. In most of the students' manuals upon British geology this explanation of the origin and position of these beds is given, and it still holds the field, for in the latest edition (1903) of Professor Archibald Geikie's Text Book of Geology we find them referred to as "a small but interesting group of sand, clay, and lignite beds, from 200 to 300 feet thick, which lies between the granite of Dartmoor and the greensand, in what was evidently the hollow of a lake." The lake hypothesis might thus be called the orthodox view, since other suggestions antagonistic thereto have not so far been able to command general attention, much less acceptance. That being the case it might be thought that little service would be rendered by dragging immature views before the public notice; but the matter has become more involved since the new Geological Survey map of the district in question has been published, inasmuch as the gravels which cap the bordering hills are now coloured the same as the Bovey lake area, thus associating the two as members of the same series which were disassociated by colour and name in the old maps.

An attempt to trace the steps which have led to this change and to examine the data upon which a new theory is being constructed, may be of interest.

The following citations are from papers by Mr. J. Starkie Gardner:—"The fossil plant remains met with in the Bournemouth beds, especially those in the marine series, are so strikingly similar to the Bovey Tracey fossils, as to make it clear to my mind that the latter have been wrongly assigned to the Miocene. I believe, in fact, that they are simply an outlier of the Bournemouth series, from which they are but eighty miles distant."[2]

"Time has, however, completely refuted upon plant evidence the theory that the Bovey beds are Miocene, and unmistakably identified them with the Middle Bagshot of Bournemouth. Upon geological evidence also the improbability is apparent of such great deposits being accumulated in a Devonshire valley without any trace of them existing elsewhere, and a theory which brings them into a defined position in the consecutive formation of the country would be a welcome one."[1]

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[1] De la Beche: Geol. Report of Cornwall, Devon, and Somerset, p. 257.

[2] *Quart.* Journ. Geol. Soc., 1879, vol. xxxv, p. 227.

These Bovey beds being contemporaneous with the Eocene at Bournemouth, "we see that this silted up lake lies in the direction whence the great Eocene river came, and must either have been in its direct course or in that of one of its affluents."[2]

The Eocene river (Hampshire basin) "must have been more than a mile in width, and the width of its valley subject to floods cannot have been less than 9 miles, and was possibly even 16 miles. The total absence of boulders and the fineness of the silt show that it flowed over a comparatively flat area, and the absence of lignite throughout a great part of its thickness that probably there were lakes or catchment basins in its course to intercept drifting timber. Possibly the Bovey Tracey lignite beds, only 80 miles distant, which are undoubtedly about the same age, may be relics of these. The complete absence of any material derived from flint or chalk shows that no chalk ranges were cut through by it, and the quartzose and granitic sand and pipeclay that its sediment must have been mainly derived from an old rock area."[3]

The following are taken from papers by Mr. Clement Reid:—"A study of the composition of the Eocene gravels shows distinctly that the rivers that brought them must have flowed from the west or south-west."[4]

"The lower Bagshot sands become coarser and more purely fluviatile westward."[5]

"It is noteworthy that the new evidence discovered in the western end of the Hampshire basin strongly supports the idea that the pipeclays of the Bagshot series are derived from the weathering of the Dartmoor granite, and that the Bovey Tracey outlier so like the deposits around Bournemouth is, as maintained by Mr. Starkie Gardner, of the same age, and deposited in the same basin, though in Devon Eocene rest directly on Palæozoic rocks."[6]

"The general conclusions arrived at from my recent work in Devon and Dorset are therefore:—1st, that the supposed litoral Cretaceous rocks near Dartmoor are Eocene, and that no trace of Cretaceous shore-line is there visible. 2nd, that, as has been for some time maintained, the Bovey beds are Eocene, not Miocene. 3rd, that the high-level plateau gravels of Haldon, like those of Blackdown in Dorset and probably those of the Cretaceous hills between the two districts, are of Lower Bagshot date and mark the course of the old Eocene river."[7]

Ignoring apparent discrepancies in an attempt to connect and summarise the general purport of these extracts, we first note that they sweep away our formerly supposed geological representative of

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[1] Geol. Mag., 1879, New Series, Decade II, Vol. VI, p. 152.
[2] Ibid., p. 153.
[3] Quart. Journ. Geol. Soc., 1882, vol. xxxviii, p. 10.
[4] Quart. Journ. Geol. Soc., 1896, vol. lii, p. 492.
[5] Ibid., p. 490.
[6] Ibid., p. 494.
[7] Ibid., 1898, vol. liv, *p. 236.*

Miocene times. Instead of considering the Bovey beds as a unique deposit within our boundaries, we are hereby directed to regard them as only a small portion of once widely extending beds that is saved from the destruction of denudation that most of the formation has met with, by sinking into the hollow in which they are now found. We also learn from these extracts that the gravels and sands which are found capping the hills bordering the Bovey area are really stratigraphically below and form the basal portion of these deposits, the whole series being of Middle Eocene age. We are to consider them further as western portions of and once continuous with the Lower and Middle Bagshot beds of Hampshire, of freshwater origin, the detrital material of an Eocene river which flowed from the west.

The following examination of some portions of this theory applies generally to the deposits in question that are to be found in the neighbourhood of Bovey, and is an attempt to ascertain whether this view, as compared with the older theory, more satisfactorily interprets the geological facts within this area, when the natural inferential and collateral questions arising from it are considered.

And first in respect to the river. Presumably as the gravels, sands, and arenaceous clays which form the lower member of this series are to be regarded as river drift, we must infer that the removal of all the chalk and a portion of the greensand that once covered the area now overlain by these gravels was also the work of this river. If so, there must have been no inconsiderable thickness of chalk lying over the Haldon area destroyed by this river, not in the usual way of cutting through it, but by sweeping the whole area of the Cretaceous deposits, entirely in some parts, and down to a portion of the Greensand in others. Accompanying this destruction was the conveying from higher elevations westward of similar material to that removed, and its distribution over the area thus eroded, i.e., the deposition of the gravels, etc., now termed Lower Bagshot beds. The coarseness of much of the material of these beds demands the assumption of a rapid current and consequently a comparatively high angle of elevation to the land westward. The size of the river is another point of remark, since its width within the district indicated as measured by the extent of these gravels, taken either north and south or east and west, must have been at least 12 miles. The present boundaries have, of course, been much narrowed, yet further east similar criteria must give even greater width. Now the length of the river could not be in proportion to the width, even though this portion might be considered a part of its estuary (which the coarseness of the detritus would scarcely warrant), for it is supposed to flow from the west or south-west. From Mr. W. H. Hudleston's address[1] before referred to it appears that only 200 miles west of South Devon the edge of the deep basin of the Atlantic is met with, the limit of the European land area in that direction and the boundary of a geologically permanent drainage area. Now supposing that the Eocene land stretched to the utmost boundary westward, and that its slope was eastward from almost its western limits, probability must be further strained to assume such a large river within so narrow a strip of land.

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[1] Trans. Devon. Assoc., 1889, p. 33.

What is more remarkable, however, is that, although so large and swift a stream, it brought down no foreign material whatever, for these gravels contain only chalk and greensand débris with some other fragments of rocks that are to be found in their immediate neighbourhood. This negative evidence must surely be of fatal import, since even though the chalk area stretched further westward than Devonshire, still it would hardly be considered possible that the whole course of the river was during its term of existence only over and through the same Chalk formation.

These gravels are assigned to the Bagshot age of the Eocene era, which means a lapse of time subsequent to the close of the Cretaceous period, during which the new Tertiary land subsided eastward, allowing the formation of the lower Eocene members, viz., the Thanet beds, the Reading beds, and the London Clay, totalling some 500 feet of new deposits, before the gravels in question are supposed to be formed from the long upraised chalk land. Now although this geological hiatus within this area must be inferred in order that the Eocene era might half spend itself before the appearance of the river to form these gravels, yet strangely and unfortunately no distinctive forms of Eocene life are found among its fossils; indeed, only such palæontological evidence is met with in them as to declare them to be simply chalk and greensand débris. May not this be taken as an indication of earlier formation than that assigned?—a supposition in keeping with the observation that the material of the deposits and conditions of formation were unsuitable for gathering and preserving contemporary biological evidence.

Now these difficulties which seem to naturally arise with the assumption that the gravels are river-borne do not present themselves when the older theory referred to by Mr. Reid (*ante*, p. 271) by the words "litoral Cretaceous rocks" are considered. De la Beche thus accounts for them:—"From the unrolled condition of a large proportion of the flints in the neighbourhood of Lyme Regis, Sidmouth, Chard, and Blackdowns, we are led to suppose that the chalk in which they were embedded may have been quietly removed from among them, and that these flints may have been let down nearly in places above which they occurred in the chalk."[1] Quoting again from Mr. W. H. Hudleston's address:—"Speaking of the geology of the neighbourhood of Dawlish, Mr. Ussher says there can be little doubt that the Cretaceous highlands of Devon, such as the Haldons, are portions of a great plain of marine denudation, and he speaks of a time when that Cretaceous tableland abutted on the flanks of Dartmoor."[2]

The facts, then, pertaining to the gravels of the area in question can be accounted for, without involving inferential difficulties, by assuming that they are of shallow sea and shore formation; that the western border of the chalk and greensand deposits becoming exposed to tide, wave, and current action, was thoroughly disturbed by these agencies, that the beds were worn down, sifted, and the materials rearranged; and that while subjected to these processes some new material was being added from the shores and streams of the bordering Dartmoor land in relative proportion to the distance from that shore.

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[1] Op. cit., p. 255.

[2] Trans. Devon. Assoc., 1889, p. 32.

Turning now to consider the plastic clay, sand, and lignite beds which overlie a part of these gravels and form such a distinguishing feature in the geology of the Bovey area, the first question that presents itself in regard to them is, what relation, in time, do they bear to the beds immediately preceding them in position? Were these deposits laid upon the gravels without any material break in time, alteration of conditions, or change of agency? The citations are not definite upon these points, but as each writer attributes the gravels and clays respectively to the agency of an eastward-flowing Eocene river it would appear as though the later author had adopted the river of the former, thus making the formations consecutive in both position and time. In respect to the latter point there does seem to be some doubt in the mind of Mr. Reid as to the exact horizon of the clays in the Eocene series, for he writes:—"With regard to the age of the lignite and pipeclay of Bovey it is difficult yet to speak with confidence. Mr. Starkie Gardner has pointed out that the flora is probably of Bagshot age, not Miocene as stated by Heer, and the resemblance of the deposits and of their flora to the undoubted Bagshot of Dorset is most striking. Still, one cannot say that the botanical evidence is conclusive, for the species are few and greatly need re-examination."[1]

Now the gravels and clays bear no relation to each other in either mineral constitution or origin, so that there does not appear any acceptable way of reconciling these facts with the hypothesis that the same river was responsible for both deposits.

The supposition is rendered more untenable by the statement on p. 271, *ante*, that "the complete absence of any material derived from flint or chalk shows that no chalk ranges were cut through by it, and the quartzose and granitic sand and pipeclays that its sediment must have been mainly derived from an old rock area." This provokes the query, how could that river flow from the west in Middle Eocene times without going over and through Cretaceous deposits?

But it is the exact mode of deposition of the Bovey clays, sands, and lignites only that we are now considering; their origin is so evident as to be beyond dispute. The authors cited declare that these beds do not form an independent deposit, but an outlier of Eocene strata that formerly extended from Mid Devon to the Isle of Wight. It should perhaps be noticed that Mr. Gardner does not appear to be quite convinced as to the exact relation of the deposits to their original basin. In quotation *ante*, p. 270, he thinks the lake theory unsatisfactory; in the next extract he seems to accept that theory. In another, p. 271, he considers the clays might have been formed in lakes or catchment basins in the course of the Eocene river; but Mr. Reid writes with conviction that the Bovey beds are simply an outlier as expressed by Mr. Gardner in citation on p. 271.

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[1] Quart. Journ. Geol. Soc., 1898, p. 236.

Now the assumption that the beds were formed in a lake by an affluent of the Eocene river does not disturb the old theory at all, and in consequence needs no comment. That the lake might have been one in the course of the main stream would raise the question, how are the clays further eastward to be accounted for if the river was cleared of its detrital material by the Bovey lake?

The consideration of the Bovey area as a 'catchment' basin would imply that close under the slopes of Dartmoor low-lying land 9 by 4 miles in dimensions received a part only of the water and detritus of a river flowing eastward along its southern border. That in this way from 300 to 400 feet of deposits were formed without the help of streams from land bordering it on the north; for although the Dartmoor granite is the undoubted origin of the clay and sand material of these deposits, yet streams coming directly into the area therefrom are precluded by the terms of the hypothesis. Now streams have flowed down that slope of Dartmoor continuously since even pre-Eocene times, so that the 'catchment' supposition can hardly be maintained in the case.

It is, however, the 'outlier' view that demands the closest consideration. This implies that the deposits were spread more or less regularly over the area before indicated, extending some 100 miles east and west. Data are wanting to get an estimate of the width of the supposed basin, but if the gravels may be used as such it might be taken to be from 12 to 25 miles westward, and about 25 miles wide towards its eastern limits. This hypothetical 'lagoon' during the deposition within it of the Middle Eocene fresh-water beds received apparently very little else than the detrital material of Dartmoor, from which the clays and accompanying sands were derived. Now, however, we may regard the distribution of these beds over this area; from the figures available respecting the present existing remnants! the supposition that they were continuous implies such an enormous amount of derived material as to seem incompatible with the reputed source of supply. Mr. Gardner accepts Pengelly's estimate of the Bovey clays as "440 feet without bottom being reached," and his own estimate of the fresh-water series of Bournemouth is from 600 to 700 feet thick. Regarding these deposits, 80 miles apart, as continuous in the light of the remarks that they "have been mainly derived from an old rock area," and "are derived from the weathering of the Dartmoor granite" (*vide ante*), we are impressed with the enormous demand made upon that comparatively small granite mass. Put into terms of roughly comparable measurement, it may be represented thus:—A part only of an area of less than 250 square miles called upon to supply material hundreds of feet in thickness over more than 1,500 square miles of surface within the narrow limits of one unit of geologic time. Does not the supposition provoke the question of possibility in place of probability?

Another consideration suggested by the 'lagoon' hypothesis is the remarkable thickness of the clay beds on the western side so near the source of origin. The material of the clay derived from the decomposition of the felspars of the granite is of extreme fineness, probably the most impalpable material forming deposits, so that it would be held in suspension longer than any other detrital material, and would be precipitated only where the water was almost, if not quite, motionless.

Consequently it does not seem to be consistent with the nature of the material in suspension that such an enormous deposit should have been made close to the foot of the steep slopes of the granite, where the rapid streams bearing the detritus would cause continual commotion and currents that would make themselves felt for considerable distances in a large tideless water area; so that the deposition of the finest material would hardly take place quite near to the stream discharges without some check to the motion of the water such as narrower land boundaries would give. One would therefore expect to find the finest and purest clay in thickest beds away from that part of the 'lagoon' where the streams entered it, while the coarser material would indicate that locality. The sands could scarcely reach the farther part of the basin until the western part was shallow enough to allow the streams to retain sufficient carrying power to convey them. But this arrangement is not found in the fresh-water deposits of the Hampshire basin, and indeed Mr. Gardner accounts for the way they occur rather by current action in an estuary than by deposition in an entirely water-covered area. The same line of thought occurs in connection with the 31 superimposed lignite beds found so near the discharging place of the streams. If there had been a much larger sheet of water than the Bovey area comprises, would it not be likely that the drift vegetation forming the lignite beds would have floated farther away before becoming waterlogged and settling down with the fine clay material?

In respect to the point whether the waters of Dartmoor did convey the Eocene deposits to the Hampshire basin there seems to be an almost absolute criterion, for any sands so carried would certainly contain a considerable proportion of tourmaline or schorl grains such as are to be met with in the sands at all levels within the Bovey area that are associated with the clays. There is no mention of such mineral in the detailed descriptions of the Eocene sands of Hampshire, which may be an oversight, but if not, the absence of the mineral must surely necessitate a reconsideration, if not of the origin of the clay, at least of how the clay became disassociated from its native matrix material, to be found in company with other siliceous deposits.

These considerations arising from the references made to the Bovey clays seem to me to militate against the 'outlier' theory in respect to these deposits, while no such difficulties present themselves in connection with the older and simpler lake hypothesis. Having elsewhere reviewed the geology of the Teign basin upon the basis of the lake theory,[1] my attention was called to views which had been nore recently propounded in respect to the clays and gravels. In ubjecting these to examination I have endeavoured to do so with cientific spirit and method, for having so far interested myself in he problems I desire to find a rational interpretation of the geology f a neighbourhood which is very familiar to me.

REVIEWS.

.—Ice or Water. Another Appeal to Induction from the Scholastic Methods of Modern Geology. By Sir Henry H. Howorth, K.C.I.E., D.C.L., F.R.S. In three volumes. Vols. i and ii. (Longmans, 1905.)

TO some books justice can be done in a short notice, but hardly to such a one as this. Reviewing "Ice or Water" in the pages f the Geological Magazine is something like condensing an ox nto a teacup, once depicted in an advertisement. Besides that—hough this reduces the quantity of material—the work is not yet omplete. We have only the first and second of three volumes, and nay thus misunderstand their author, as we lack his final summing p. Here, however, we are probably saved from any grave error by lucid and rather lengthy preface, and by being told that the book s virtually a continuation of those learned works with which we are ll familiar—"The Mammoth and the Flood" and "The Glacial Nightmare." It may therefore suffice to state, as shortly as possible, he contents of these two volumes, adding, as the book is entitled n appeal to induction, one or two comments on the author's use f this method of reasoning.

In "The Mammoth and the Flood" Sir H. Howorth, as he tells s, explains certain well-known phenomena by "a cataclysm on widespread scale, which caused very important dislocations of the arth's surface, accompanied by gigantic tidal waves" (would not he dislocations cause the cataclysm, if that word be used in the rdinary sense?); and in "The Glacial Nightmare" he prefers it, fter a critical discussion, to the invocation of a Great Ice Age as an xplanation of the "last touches and alterations made in the onfiguration of a large part of the earth's surface and of the soft leposits which cover it."

The opening chapters of the present work are devoted to a critical xamination of the Astronomical and Meteorological Theories of an ce Age; from which both, and especially the former, emerge n a dishevelled condition. The author next dismisses as unsatisactory other explanations, some of them only modifications of roll's, till the stage, as at the end of "Hamlet," is strewn with the slain, and he clears away the corpses by declaring all known glacial theories to be inadequate. After this slaughter grim and great, he turns aside to discuss air, wind, and water, rain, rivers, and sea, as agents of denudation or deposition, afterwards subjecting ice to a very rigid cross-examination as to its boasted powers as an eroder and excavator. He then tells us what subterranean forces can do as fashioners of the earth's surface, informing us by the way that corries and cirques are due to subterranean movements no less than the breached craters of Auvergne and even the complete one of Cotopaxi (vol. i, p. 535). In the second volume he brings forward "some *à priori* arguments against the Great Ice Age," which, however, prove to be mainly discussions of the supposed evidence of ice-action in the Permian breccias of the Midlands, the Gondwana Series of India, and similar deposits in Australia, Tasmania, and South Africa. None of these, he maintains, allows us to think that the "Ice King ever took such a liberty as to put his arms round the waist of our mother earth." If, then, we cannot attribute the transport of these blocks to ice, we are driven to seek some other cause. He next examines the biological evidence for the so-called Ice Age and the Interglacial Periods, besides that for the alleged southern frontier of the Drift beds and their rock materials, and maintains these materials to be derivative, which, in a certain sense, is indisputable. Next he discusses the bearing of the external features of the Drift on the theory of an Ice Age, and concludes the volume with a description of the Arctic regions in Glacial times, maintaining the ice in these to be now about at its maximum.

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[1] Trans. Devon. Assoc., 1903, pp. 631–645.

The present work has all the characteristics of its predecessors. No pains have been spared in searching the literature of the subject. Whether we accept the author's conclusions or not, we owe him a debt of gratitude for bringing together in a readily accessible form such a mass of information; though, as the work may remain for some time incomplete, we should have been grateful had each volume been provided with an index, or at least with a much fuller table of contents. The author also would have done well had he prevailed on some geological friend to read over his proofs, for typographical errors, notwithstanding a considerable table of errata, are still rather too numerous. These trifling blemishes, however, cannot detract from the value of "Ice or Water" as a book of reference. But, great as this undoubtedly is, the work, we think, has the defects of its qualities. Though professing to be an appeal to induction, its methods are forensic rather than strictly scientific. Advocates and philosophers alike often reason inductively, but with this difference: the one selects and groups his facts so as to sustain his case; the other, after placing all, so far as he can, in right perspective, draws from them the inferences which seem the most accordant. At least, this is the true inductive method, though we cannot say that it is always followed by enthusiastic glacialists, whom we gladly leave to the author's tender mercies. Again, his method of conducting his case occasionally reminds one of that eminent advocate who, some sixty years ago, won the sobriquet of

'Apple-pip.' This may serve as an example. Stones in boulder-clays are frequently striated, and most geologists now accept those marks as indicating the action of ice. This interpretation he disputes, proposing, as we think, improbable alternatives. Excellent authorities declare that striation may be produced by the friction of stones one against another when embedded in a rock-mass; they may be of the nature of slickensides. That is undoubtedly true, but stones thus marked are not common, and only occur under special circumstances. He tells us they may be scratched accidentally by the passage of a plough or harrow, and, as he might have said, by boys using them as substitutes for a toboggan; these, again, are local in occurrence and can usually be distinguished. They may be scratched by mutual friction when swept along by a rapid stream. That also is true, but anyone who has examined the pebbles in a torrent bed or on the sea-shore knows that such markings are few and far between. Sir H. Howorth practically ignores two other facts: the abundance of these striated pebbles in many British boulder-clays, and their occurrence in the till of the Swiss lowland, from which we can track them up to the existing glaciers, while he lays stress upon the fact that they are rare in moraines connected with such glaciers. Naturally they are, because at the present day most of the morainic material has travelled on, not under, the ice, but they may be found if we hunt for them in the right place.

His method of citing authorities is also, we think, distinctly forensic. Science is progressive, so that, though the facts recorded by a careful observer may hold good for all time, his interpretation of them may prove to be erroneous. But if one of "his masters," say Murchison, whom he seems to hold in special veneration, has referred some phenomenon to diluvial or other form of catastrophic action, he is perfectly content; forgetting that the efforts of ice were practically unrecognised in Britain sixty years ago. The same uncritical use of quotations has led him to give renewed currency to Buckland's mistaken reference of the quartzite pebbles, so abundant in the Bunter beds of the Midlands, to the Lickey Hills. But adverse authorities meet with much less reverential treatment. If Colonel Feilden states that a stone in an Arctic deposit is ice-scratched, that is followed by "(say scratched, H. H. H.)." Considering that the former's experience in the field has been so much the greater, to treat his writing as a schoolmaster does a boy's exercise is a rather strong measure.

But though the author too often reminds us of a skilled cross-examining counsel, we gladly admit that some of the extremists in glacial matters leave the witness-box in a very damaged condition. He has a most uncomfortable habit of taking up a bunch of puppet hypotheses and, as it were, knocking their heads together. But he succeeds better as a destroyer than a constructor. He takes away an ice-sheet to put a deluge in its place. But we are entitled to ask for some proof that the substitute could produce such deposits as the drifts of the Norfolk coast or transport such boulders as it contains. For a deluge to lay down a rather large group of stratified sands and clays is no easy feat, and for it to transport masses of chalk several thousand cubic feet in volume, perhaps for some miles, would be yet more difficult. It is not explained by quoting cases of the effect of waves in violent storms or of what a rush of water has done when pent up in a narrow valley. The great chalk and other limestone erratics of the more eastern part of England, the smaller but still very considerable boulders of the more western and central districts, have often been moved over a comparatively open district, where the mightiest rush of water would quickly lose its force, or have been transported across the general trend of the valleys. So, though, as we have already said, Sir H. H. Howorth deserves the gratitude of every student for these full storehouses of glacial literature, we think that (to reverse the old saying) in seeking to avoid Scylla he has been swept away by Charybdis. T. G. B.

II.—MEMOIRS OF THE GEOLOGICAL SURVEY OF ENGLAND AND WALES.

THE GEOLOGY OF THE NORTH STAFFORDSHIRE COALFIELDS. By WALCOT GIBSON, B.Sc., F.G.S.; with contributions by GEORGE BARROW, F.G.S., C. B. WEDD, B.A., F.G.S., together with a Palæontological Account and List of Fossils by J. WARD, F.G.S. pp. vii and 523, with 8 plates and 21 illustrations in the text. (London: printed for His Majesty's Stationery Office; sold by E. Stanford. Price 6s.)

THIS memoir contains a detailed account of the Coalfields of North Staffordshire, especially those of the Pottery and Cheadle Coalfields.

The Palæontology of the Pottery Coalfield is described in detail by Mr. John Ward, and is accompanied by full lists of the fossils. Details of numerous pits and quarries are given in an appendix, also a complete bibliography. There are numerous illustrations, including a colour-printed map of the Cheadle Coalfield on a scale of one inch to a mile, and six plates of the principal fossils of the Coal-measures.

The Triassic and Glacial deposits are described in separate chapters. The economic products of the Pottery Coalfield are described in chapter xii. The account includes the question of the future coal-supply of the district, in addition to a description of the local building-stones, clays, and marls, supplemented by an enumeration of the chief sources of water supply.

The original Geological Survey was made on the Old Series one inch map, Sheets 72 N.W., 73 N.E., and 81 S.W., published during the years 1852–1864, the Coal-measures having been mapped by Sir W. W. Smyth, Permian and Trias by Professor E. Hull, and the subdivisions of the 'Yoredale Rocks' and Millstone Grit by Professor A. H. Green. The memoir on the Iron Ores of North Staffordshire, by Sir W. W. Smyth, published in 1862, contains a summary of the geological features of the coalfields; and brief accounts of the northern end of the Pottery Coalfield, known as the Biddulph Trough, were published in 1866 in the memoir on the Geology of Stockport, Macclesfield, Congleton, and Leek, by Professor Hull and Professor Green.

The re-survey on the six inch scale was commenced in 1898 and completed in 1901. The Pottery Coalfield was surveyed by Messrs. W. Gibson and C. B. Wedd, and the Cheadle Coalfield by Mr. George Barrow.[1] The area is included in the New Series one inch Sheets 110, 123, 124. Drift and Solid Editions of Sheet 123, with an explanatory memoir, were published in 1902. A description of the Cheadle Coalfield, with an accompanying geological map (part of Sheet 124), was published in 1903.[1] A sheet of Vertical Sections, giving sections of shafts in the Pottery Coalfield, was published in 1901. Sheet 110, which includes a small portion of the Pottery Coalfield, has been prepared for publication; while thirty-five quarter-sheets on the six inch scale, including the whole of the ground described in this memoir, were published with geological lines in 1904.

Although this volume contains the detailed descriptions by each geologist of the area surveyed by himself, it has been largely written and edited by Mr. Walcot Gibson, who personally carried out the greater part of the field-work. In the Palæontological portion, the Survey fortunately obtained the assistance of Mr. John Ward, of Longton, whose knowledge of the district extends over nearly fifty years. Mr. Ward has now contributed copious lists of fossils, together with a palæontological statement in reference to them, the result of his long-continued researches in the North Stafford Coalfields. In the preparation of these lists Mr. Ward has been greatly indebted to Dr. R. H. Traquair, F.R.S., and Dr. A. Smith Woodward, F.R.S., for recording the Fossil Fishes; to Mr. R. Kidston, F.R.S., for the Plants; and to Dr. Wheelton Hind for cataloguing the Lamellibranchs, and in the preparation of the lists of Invertebrata generally. Mr. J. T. Stobbs and many other local geologists have given much assistance to the re-survey of the Coal-measures, and added greatly to the value of the present memoir.

Four of the plates, accompanying the lists of fossils, illustrate the Fishes of the Staffordshire Coalfield, and two are devoted to the Lamellibranchia described by Dr. Wheelton Hind in the Palæontographical Society's volumes.

In the account of the Carboniferous rocks it has been found advisable to adopt purely descriptive terms for the various subdivisions. Though, as is well known, the vertical distribution of both plants and fishes points to a twofold division of the Carboniferous rocks, the exact position and nature of the boundary-line has not yet been determined for North Staffordshire. For the old term 'Yoredale Beds' the term 'Pendleside Series,' introduced by Dr. Wheelton Hind and Mr. J. Allen Howe, seems preferable, since it only implies a correlation with similar beds occupying the same stratigraphical position on Pendle Hill in Lancashire.

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[1] Reviewed in GEOL. MAG. for 1903, pp. 471, 473.

For similar reasons the terms Upper, Middle, and Lower Coal-measures have not been adopted; since the positions of the palæontological boundary lines or zones, which may give a definite significance to the terms, have not been determined with accuracy.

It is evident, as pointed out by Jukes long ago, that as regards the higher portions of the Coal-measures, North Staffordshire presents the type-development for the Midlands. In that region Mr. Gibson has established a definite stratigraphical sequence in the comparatively barren strata which conformably overlie the productive Coal-measures, and he has also proved that the same sequence may be recognised in the other coalfields of the Midland area.

The points of special economic interest are given in a separate chapter, considerable attention being paid to the future development of the coalfield.

The portion of the memoir descriptive of the Cheadle Coalfield is largely a reprint from a separately published memoir on this small coalfield by Mr. G. Barrow.[1] Since the publication of that memoir the prediction there made that the Dilhorne Coal underlay the Delphouse area has been verified by actual sinking.

The formations and groups of rock in North Staffordshire are arranged in the following descending order of sequence, the sedimentary and igneous rocks being kept distinct:—

TABLE OF FORMATIONS.

Sedimentary.

PLEISTOCENE AND RECENT.		Recent and Post-Glacial	Alluvium, peat, and river gravels.
		Glacial	Clays, sands, gravels, and erratic blocks.
TRIAS		Keuper	Marl, soft flags, and building-stones.
		Bunter	Sandstones and conglomerates.
CARBONIFEROUS.	COAL-MEASURES.	The Red and Grey Series	Red sandstones and marls (Keele group).
			Grey sandstones and marls (Newcastle-under-Lyme group).
			Red marls and green grits (Etruria marl group).
			Grey shales and marls, thin coals, and bands of Blackband ironstone (Blackband group).
		The Grey or chief Coal-bearing Series	Grey shales, sandstones, and marls, with numerous seams of coal and clay ironstones in upper portion.
		Millstone Grit	Grits and shale.
		Pendleside Series	Grits, crowstones, and shales.
		Carboniferous Limestone	Massive limestone, with shale and thin beds of limestone at top.

Igneous.

A. Interstratified, or contemporaneous with the formation among which they lie.
Tuffs and agglomerates in the upper part of the Carboniferous Limestone.
B. Intrusive or subsequent in date to the formations among which they lie.
Basalt and dolerite in dykes traversing the Carboniferous and Triassic formations.

The district occupied by the coalfields of North Staffordshire is situated at the south-western termination of the Pennine Chain—so well known as forming the backbone of England. This elevated tract, though consisting in the main of one great anticlinal uplift, of which the core is composed of the periclinal Carboniferous Limestone massif of the Derbyshire Hills, and off which newer Carboniferous rocks continue to succeed each other, until on its eastern flanks in Derbyshire and on its western flanks in Staffordshire the Coal-measures of the respective coalfields crop out, is in reality made up of several lesser anticlinals consisting in modern technical language of an 'anticlinorium.' It is within the troughs between these saddles that the Coal-measures constituting the Cheadle, Shaffalong, and Pottery Coalfields, and the smaller basin of Goldsitch Moss have been preserved. Moreover, the shape of the fold has determined that of the coalfields. Thus the Cheadle Coalfield is somewhat oval in shape; that of Shaffalong long and narrow; while the Pottery Coalfield is of a triangular form, owing to the fold contracting rapidly in the north and widening out in the south. To this basin there succeeds on the west side of the coalfield a conspicuous anticline composed of Coal-measures in the south and of Lower Carboniferous rocks in the northern part of the district.

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[1] See footnote ante.

The area, especially the Pottery Coalfield, has been further complicated by numerous dislocations, frequently of very great magnitude, which, it will be observed, do not affect the overlying Triassic rocks to anything like the same extent. These disturbances consist, on the east side of the Pottery Coalfield, of a belt of highly inclined strata, bordering the coalfield, and ending at Hulme in a series of fractures which depress the Coal-measures over 200 yards to the east; in the central portion of the coalfield the Apedale Fault, which at one spot attains the magnitude of over 600 yards, plays a still more important part in the coal-mining industry of the district by introducing a broad belt of barren measures beneath which coal-seams lie at considerable depths; while on the western side a fault of even greater magnitude extends along the whole length of the district, and for the present forms the limit of all coal workings in this direction.

Between the closing of the Carboniferous and the opening of the next geological epoch—the Trias—a vast interval of time elapsed, of which the extent will be realised when it is stated that the major part of the folding and faulting took place before the newer formation was laid down. In addition, huge masses of Carboniferous strata were removed; and it is on the denuded edges of these frequently highly inclined rocks, or in the deep hollows worn into them, that the Red Rocks of the Trias resting indiscriminately on the older formation were almost horizontally deposited. Such is the disposition of the Red Rocks on the eastern and southern margins of Pottery Coalfield; but on the west the junction of the two systems is, for the most part, a clearly defined line determined by the fault previously mentioned. Space precludes our giving a longer notice, but we cannot pass by this memoir without expressing our pleasure at the progress of the work of the Survey in the last decade, and the great improvement which has taken place in the style of the later publications, and especially in the quality of the plates and illustrations which accompany the text in the present excellent memoir, the price of which is fixed at six shillings.

REPORTS AND PROCEEDINGS.

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Geological Society of London.

April 19th, 1905.—Horace B. Woodward, F.R.S., Vice-President, in the Chair. The following communications were read:—

1. "The Blea Wyke Beds and the Dogger in North-East Yorkshire." By Robert Heron Rastall, B.A., F.G.S.

The author describes the type-section at Blea Wyke in detail, dividing the rocks into the following divisions, enumerated in descending order:—

		ft.	in.
5.	Dogger	11	6
4.	Yellow Beds	53	0
3.	*Serpula* Beds	10	6
2.	*Lingula* Beds	32	0
1.	*Striatulus* Shales.		

Descriptions and fossil lists from these divisions are given, and then the succession is compared with that shown at Peak Alum Works, Saltwick and Whitby, Sandsend and Kettleness, Boulby Cliff, Falling Foss and Littlebeck, Eskdaleside and Grosmont, Glaisdale, and along the north-western escarpment of the Cleveland Hills. A complete series from the Lias to the Lower Estuarine Series is seen only at Blea Wyke; at other sections the transition from Alum Shale to Dogger is abrupt, and the characteristic passage-beds are absent. In all these sections there are signs of unconformity, and in most cases there is a well-marked pebble-bed of peculiar character. In many localities the upper surface of the Lias is worn into distinct hollows, in which lenticular masses of sandstone have been deposited. Probably shallow-water conditions and strong currents prevailed over a wide area. This was most likely brought about by a slow elevation which was more prominent in the northern part of the area, as though the Peak Fault were partly of pre-Oolitic date. This fault probably formed a submarine cliff, and in the still waters at its foot the Blea Wyke passage-beds were formed. North of the fault erosion was active, planing down the Lias to a more or less level surface, with occasional deep hollows due to strong currents. Eventually the upward movement ceased, and the hollow below the fault was filled up, so that the Dogger was laid down as a continuous bed over the whole area. The uplift to the north was probably much greater; consequently the whole of the Upper Lias was removed, and the Middle Lias reached and denuded. Pebbles derived from the Middle Liassic Ironstone occur in the basement conglomerate of the Wainstones, according to Prof. P. F. Kendall.

2. "Notes on the Geological Aspect of some of the North-Eastern Territories of the Congo Free State." By Gaston Félix Joseph Preumont. (Communicated by John Allen Howe, B.Sc., F.G.S.) With Petrological Notes by J. Allen Howe, B.Sc., F.G.S.

This paper is a brief sketch of the geological structure of the northern part of the Congo State, from Buta on the River Rubi and *Bima* on the Uelle in the west, to Lado and Dufile on the Nile.

In the whole of this region, the only post-Primary rocks met with, other than those of comparatively modern alluvial origin, were chocolate-coloured shales (Buta Shales) and sandstone, and an oolitic limestone, on the extreme west.

From the Lipodongu Falls on the Rubi, and thence through Poko to Rungu, on the Bomokandi River, none but granitic rocks (gneisses) were observed. Along the Uelle, from Bima to Bomokandi, the same rocks were seen.

In the centre of the region mica-schists, quartzites, and similar metamorphic rocks replace the granite wholly or in part. A noticeable feature here is the presence of a range of isolated hills, composed almost completely of great beds of magnetite and hæmatite occurring in the schistose series.

In the south-eastern portion of the region visited, between the Uelle-Kimbali and Bomokandi Rivers, a great plutonic massif is laid bare in the mountainous district of Arebi.

From the presence of iron-ore and schists at Mount Tena on the south-west and analogous rocks at Mount Gaïma on the north-west side of the massif, and from the fact that the dip is in each case strongly away from the intervening country, it is suggested that these rocks have been uplifted and tilted by the plutonic complex, and that the beds of Mount Tena and Mount Gaïma are identical in age.

The plutonic massif itself contains microclinic gneiss and abundant diabasic rocks, and the same rocks in all stages of dynamo-metamorphism.

On the boundary between the Congo State and the Bahr-el-Ghazel, several hills made up of rocks of coarse gneissose and schistose character are described; some of these rocks are rich in tourmaline, kyanite, and garnet in large crystals.

From the region of the Enclave de Lado and the western side of the Nile between Lado and Dufile, mica-schists, quartzites, and microcline-gneisses are described.

The alluvium of a large part of the Uelle is covered, on the higher ground, by a deposit of limonitic conglomerate; in places this may be due to the decomposition *in sitû* of the alluvium, but in the neighbourhood of the iron mountains a sort of passage may be seen between a conglomerate of fresh iron-ores and the more general type of limonitic conglomerate (laterite ?).

CORRESPONDENCE.

THE DISCOVERY OF THE SOUTH-EASTERN COALFIELD.

SIR,—In the last edition of "The Coalfields of Great Britain" Professor Hull gives an account of the discovery of the above coalfield which cannot, in the interests of fairness and truth, be allowed to pass current without correction.

"The credit," he writes (p. 282), "of experimentally demonstrating the existence of coal-seams below the Chalk is due to Mr. Francis

Brady, Engineer of the Channel Tunnel, under the advice of Professor Boyd Dawkins, F.R.S., and an experimental boring was commenced in a position at the foot of Shakespear's Cliff, near Dover, in 1895–6."

It would be difficult to compress more errors into one sentence than are in the above quotation. The only statement which is true relates to the place of the boring. The credit of experimentally proving the existence of the coalfield is not due to Mr. Francis Brady, but to Sir Edward Watkin, Chairman both of the South-Eastern Railway and of the Channel Tunnel Company, who acted under my advice, and sent on to me all reports connected with the boring. Mr. Brady was simply engineer in charge of the borehole, and acted under Sir Edward Watkin's instructions. I never had occasion to advise Mr. Brady. Nor was the boring "commenced in 1895–6." It was begun in 1886, and from that time down to the discovery of the Coal-measures in 1890, the work of identifying the specimens and fixing the horizons of the strata penetrated—or, in other words, all the geology—fell to me. The last of a long series of reports to Sir Edward Watkin is dated July 8th, 1891.

All this is ancient history. The progress of the boring was recorded by me, from time to time, in the Reports of the British Association (1887, 1890, 1899), and in the publications of the Royal Institution (June 6th, 1890) and of the Manchester Geological Society (1890–3–4–7). They also were communicated to the public at large in *The Contemporary Review* (April, 1890), in *Nature* (March 6th, 1890), *The Colliery Guardian*, and *The Iron and Coal Trade Review*. Nor is the attribution of the credit to the wrong man new. An attempt was exposed as far back as 1897, after a full debate before the Manchester Geological Society, in which Sir Edward Watkin's claim was amply vindicated. Still later the history of the discovery was dealt with in my statement on the Buried Coalfields of Southern England, prepared at the request of the Royal Commission of Coal Supplies in 1903 (Final Report, pt. x, p. 28).

It is not, therefore, from lack of sources of information that Professor Hull has written the above paragraph in a work which professes to give the last word on British coalfields. I write this in justice to the memory of an old friend, who proved the truth of Godwin-Austen's theory by practical experiment, the first of a series which is likely to yield, in the future in Kent, important economic results, similar to those brought about in the past by similar borings in Northern France and Belgium. W. Boyd Dawkins.

Manchester.
May 5th, 1905.

MOUNTAIN-BUILDING.

Sir,—The theory that mountainous areas have been produced by lateral thrust crushing and compressing large areas of country is, I think, now generally accepted; for it has been proved that such mountainous regions as have been carefully surveyed are found to have the strata bent and folded in such a manner as to cover a much smaller area of country than that upon which they must have been deposited. It has not, however, yet been conclusively demonstrated how such thrust is produced. The hypothesis that cooling and consequent contraction is a sufficient cause has been shown to be untenable; the amount of compression such a contraction is capable of producing being quite insufficient to cause the amount of rock-folding required to produce our great mountain ranges.

As far as I am aware, no other theory based upon a possible reduction in the diameter of the earth has been advanced which seems satisfactory. In default of such an explanation I would suggest that we assume that over large areas of the earth's surface there is an actual expansion of the crust, such expansion compressing the weaker portions into the folds forming mountain ranges.

A probable cause of such an expansion of the crust I should like to draw attention to. It may, perhaps, have been suggested before, but if so I do not remember to have seen it.

As profound changes in the physical features of the earth's surface have been produced by apparently insignificant agencies, we must be prepared to find that some agency which at first sight seems quite inadequate is really the one which is producing the results.

A simple experiment will illustrate the theory I wish to suggest for consideration. If a strip of thin sheet lead have two lines drawn across it near the ends, and it be rolled up into a coil about one inch diameter, and then flattened out again, the bending will be found to have lengthened it about 0·2 per cent., and each time the operation is performed further lengthening will be produced. If continued flexure is capable of expanding slips or sheets of lead and many other materials, it may be argued that the earth's crust may undergo extension under the slight flexures the sun and moon produce. Under such flexure it is conceivable that vertical joints might have mineral matter thrown down in them, as they partially opened and closed, and mineral veins of various kinds be thus formed. Or when the pressure at any point is relieved by flexure, matter previously in solution might be thrown down and not be redissolved when the pressure again came on.

It would be interesting to consider the relationship mountain ranges bear to the great plains where it is conceivable expansion is taking place and to the positions of maximum distortion the sun and moon could produce. Some connection there certainly appears to be between the positions of mountain ranges, the great plains, and the direction of the axis of the earth.

As the moon always presents the same face towards us, unless the sun would be a sufficient cause, there should be no great mountain ranges similar to those on the earth. Indeed, on the moon the surface features are apparently produced by volcanic eruptions and ejections of rock or dust into a very attenuated atmosphere.

R. M. Deeley.

Melbourne House, Osmaston Road,
Derby.

MISCELLANEOUS.

GEOLOGICAL SURVEY OF ENGLAND.

Mr. E. T. Newton, F.R.S., F.G.S., of the Jermyn Street Museum, retired from the office of 'Palæontologist' to the Geological Survey on May 4th, carrying with him the regret and esteem of a large number of friends and colleagues with whom he has served for forty years.

Dr. F. L. Kitchin, M.A., F.G.S., assistant palæontologist in the Museum, has been appointed to succeed him.

GEOLOGICAL SURVEY OF IRELAND.

THE GEOLOGICAL SURVEY OF GREAT BRITAIN AND IRELAND.—The Irish Branch of the Geological Survey has been transferred to the Department of Agriculture and Technical Instruction for Ireland, and placed under the immediate direction of Professor G. A. J. Cole.

The Geological Survey in Ireland was begun at about as early a date as that in England. Indeed, at the commencement of the Trigonometrical Survey, Colonel Colby expressed his opinion that the work "should be considered a foundation for Statistical, Antiquarian, and Geological Surveys." About the year 1832 Captain (afterwards General) J. E. Portlock undertook the formation of a geological department, and in 1837, by Colonel Colby's desire, he formed at Belfast "a museum for geological and zoological specimens, and a laboratory for the examination of soils." From that date the Geological Survey became an organized branch of the Trigonometrical Survey under the Master-General and Board of Ordnance. In 1840 the Belfast Museum was broken up, and everything connected with the geological department was moved to Dublin.[1] About four years later the Geological Surveys were placed under the Office of Woods and Forests, and Sir H. T. De la Beche then became Director-General of the Geological Survey of the United Kingdom. The first Local Director for Ireland was Captain (afterwards Colonel Sir Henry) James; he was shortly succeeded by Dr. Thomas Oldham, who held office until 1850, when Professor J. B. Jukes[2] and after him Professor E. Hull filled the post of Director. Meanwhile in 1854 the Geological Survey was transferred to the Science and Art Department, which in recent years has been merged in the Board of Education.

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[1] Preface to Portlock's Report on the Geology of Londonderry, etc., 1843.

[2] See Address by Jukes, "On Her Majesty's Geological Survey," delivered at the Museum of Irish Industry, 1866; 8vo; Dublin, 1867.

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE V. VOL. II.

No. VII.—JULY, 1905.

ORIGINAL ARTICLES.

I.—NOTES ON BRITISH DINOSAURS. PART III: *STREPTOSPONDYLUS*.

By Dr. FRANCIS BARON NOPCSA.

(PLATE XV.)

AFTER having studied a bipedal and a quadrupedal Orthopodous Dinosaur I thought it desirable to turn my attention to a bipedal representative of the Saurischian order.[1]

Though *Streptospondylus* is by no means an exclusively British Dinosaur, since the type-specimen is preserved in the Jardin des Plantes in Paris, and was described under the names *Streptospondylus* and *Megalosaurus* by Cuvier and Gaudry, still, the only other specimen known, and by far the best, is in Mr. J. Parker's private collection at Oxford. It is to Mr. Parker's kindness that I owe the possibility of studying and drawing what may be called one of the most complete Theropods ever found, while in the Paris Collection *Streptospondylus* is only represented by several vertebræ, a fragment of the femur, and the distal part of the tibia with the corresponding astragalus. Mr. Parker's specimen includes the skull, most of the cervical, dorsal, sacral, and some of the caudal vertebræ, the scapulo-coracoid, parts of both humeri, the ilium, ischium, parts of the pubis, both femora, tibiæ, and fibulæ, some tarsal and all the metatarsal bones, and several phalanges.

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[1] The quite exceptional economic *rôle* of Dinosaurs during the greater part of the Mesozoic era justifies, I believe, the quite exceptional term 'subclass Dinosauria.' The term Opisthocœlia, as recently and persistently used by some American authors, is decidedly a misnomer, for besides being absolutely misleading—since opisthocœlian vertebræ occur among Sauropoda, Theropoda, and Orthopoda—it was originally not even used for a defined group of Dinosaurs, but for what might be called a *potpourri* of Dinosaurian and Crocodilian reptiles. If one wants to emphasize the fact that Theropoda and Sauropoda form a unit in consequence of their showing greater affinities to each other than to the Orthopoda, cf. Hulke's paper on *Dystrophæus* the term Saurischia, as clearly defined by Professor Seeley, is applicable to these reptiles. I desire to protest most energetically against the use of the term 'Opisthocœlia.'

Since a detailed description of ***Streptospondylus*** is far beyond the scope of this paper, I intend to publish such a description in the *Beiträge zu Geologie und Palaeontologie* (Vienna), and here, in accordance with my previous Notes on British Dinosaurs, only the most salient points will be mentioned. First of all, it has to be remarked that Mr. Parker's fossil indicates a much smaller and, as the structure of the sacrum shows, a more immature individual than that in the Paris Museum.

The *skull*, which is altogether missing in the Paris specimen, is nearly complete in the Oxford individual, but in consequence of being imperfectly freed from the matrix I could only identify maxillary, præmaxillary, dentary, basis cranii, and quadratum. The greatest possible disproportion is to be remarked between the facial and the cerebral region. The huge jaws are built after the *Megalosaurus* pattern, and the same is also true with regard to the long, compressed, trenchant, and serrated teeth. There exist two, perhaps even three, anteorbital apertures, as in *Creosaurus* and *Megalosaurus*, while in *Ceratosaurus* there is only one. The quadratum is relatively short and points to the existence of a *Creosaurus*-like quadrato-squamosal arch. The short basis cranii shows a strong transverse expansion of the brain in the region of the vagus nerve. The brain-cavity was a good deal larger than the neural canal in the sacral region, and its large size[1] is easily explained by the comparatively high intelligence that *Streptospondylus* must have possessed as an agile carnivorous reptile. Tubera basi-occipitalia seem to be wanting. The diameter of the ball-like occipital condyle cannot have exceeded 2·5 cm.

Vertebræ. The foremost cervical vertebræ are remarkable for their small size, the centra being only 4 cm. long and 2·5 cm. high, while the posterior cervicals attain 6·0 and 3·5 cm., and some dorsals even 8 and 4·5 cm. The neural spines are but feebly developed; the arch shows, much like the primitive Sauropoda, a complex system of diapophysial, oblique, præzygapophysial, postzygapophysial, and horizontal laminæ, and differs in consequence from all the other known Theropods. The centra of the cervical vertebræ are unlike those of *Ceratosaurus*, *Creosaurus*, and the Triassic Theropods, strongly convex in front, deeply concave behind, and show large pleurocentral fossæ.

In the dorsal vertebræ the antero-posteriorly blade-like neural spines are better developed than in the cervicals, the arch is again supported by different laminæ, and the centra pass from a convexo-concave to a plano-concave and further on to a nearly biconcave stage. As we pass backward along the dorsal region the pleurocentral cavities become gradually less pronounced, so that in the posterior dorsals they are altogether wanting. The centra of the sacral vertebræ, though united in the Paris specimen, are free in the *Streptospondylus* in Mr. Parker's collection and show here saddle-shaped intersacral articulations.

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[1] I am fully aware this expression seems a euphemism when one thinks of modern reptiles, but it is not so when one thinks of such vegetable-feeders as *Stegosaurus* or *Triceratops*.

The number of the sacral vertebræ seems in *Streptospondylus* to ave been augmenting during lifetime from 3 to 4, perhaps even 5 or more.[1] In general the sacrum shows a great resemblance to hat of *Megalosaurus*, whereas in consequence of the development f different laminæ in the dorsal vertebræ—a feature absent in *egalosaurus*—these parts as well as the cervical region are totally ifferent in these two reptiles.

The biconcave and hourglass-shaped, transversely cylindrical audal vertebræ in *Streptospondylus* are likewise different from the imilarly biconcave and constricted but transversely wedge-shaped audals of *Poikilopleuron*.[2] As in the caudals of most Dinosaurs, he posterior facet for the chevron bone is much more marked than he anterior, which in this case is nearly altogether wanting.

The rod-like chevrons are both distally and proximally united; they re less compressed and comparatively shorter than in *Iguanodon*, nd they are supposed not to have extended so far backwards.

Scapulo-coracoids. Even in the immature Oxford specimen the capula and the coracoid are firmly united. The blade-like scapula is omewhat concave on the inner side and in consequence somewhat onvex on the outer, and is much more slender than in *Megalosaurus*, howing in its upper half that the borders are parallel. Inferiorly t expands rapidly towards the margin of the coracoid. It forms, ith the semicircular coracoid, a very shallow glenoidal fossa of ectangular outline. There is no scapular crest or acromion-like rocess; these are altogether wanting.

Humerus. As in all Theropoda, the humerus is very weak, but erfectly distinct from the same much more massive bone in *egalosaurus*, or the more slender but still powerful humerus in *oikilopleuron*. The different development of the radial crest in each ase affords a good characteristic.

Pelvis. The imperfect ilium shows in general, as pointed out by hilips, some resemblance to *Megalosaurus*; the proximally expanded, istally rod-like ischium seems, however, to be somewhat different. he pubis shows no obturator foramen.

Posterior limb. The femur is somewhat longer than the tibia. he head of the femur shows quite a distinct neck, the rochanter major is weaker than in *Allosaurus* and situated lower han the head, the well-developed fourth trochanter, situated at the eginning of the upper third of the femur, shows the *trochanter en rête* pattern. The shaft of the femur is somewhat curved and early cylindrical in section.

Comparing the outline of the fourth trochanter of *Streptospondylus* r *Allosaurus* with the figure given by Hulke for *Zanclodon* or the utline visible in *Euskelesaurus* (in the Vienna femur), and then the same part in the Senonian ***Megalosaurus Bredai***, one remarks that the same sort of change and diminution as I pointed out among the Ornithopodidæ can also be traced among the Theropoda, in consequence of which I feel unable to accept Hulke's statement that in the Theropoda the *trochanter en crête* represents a more primitive type than the pendant trochanter.

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[1] It is quite a common thing to find in the synsacrum of the Upper Cretaceous inosaurs 8–10 vertebræ, lumbosacrals, sacrals, and caudosacrals firmly united. esides *Claosaurus* and *Triceratops* this is also the case in the sacra of two not yet escribed Transylvanian Dinosaurs.

[2] Careful original studies have convinced me that the type-specimens of *Poikilo-euron* and the Stonesfield *Megalosaurus* (*M. Bucklandi*) are perfectly distinct.

Distally the femoral ectocondyle of *Streptospondylus* shows a smaller posterior projection, much like that in *Megalosaurus*, *Allosaurus*, and the bird *Apteryx*, while in *Iguanodon* and some birds (for example, *Cygnus*) this part is constructed after another fashion. The distal end of the strong tibia is one of the few fragments of limb bones preserved in the Paris specimen, but this, I regret to say, has been described and figured as *Megalosaurus*, and only the complete tibiæ of Mr. Parker's specimen show that the fragment in reality belongs to *Streptospondylus*, from which it has been separated for nearly a hundred years.

As the proportion of femur and tibia among Dinosaurs seems to be of the greatest interest, since it appears that among all Dinosaurs there exists a tendency to elongate the femur, a list of ten Dinosaurs is here given in which the proportion of femur to tibia is expressed according to the formula ÷ femur : tibia = x : 1.

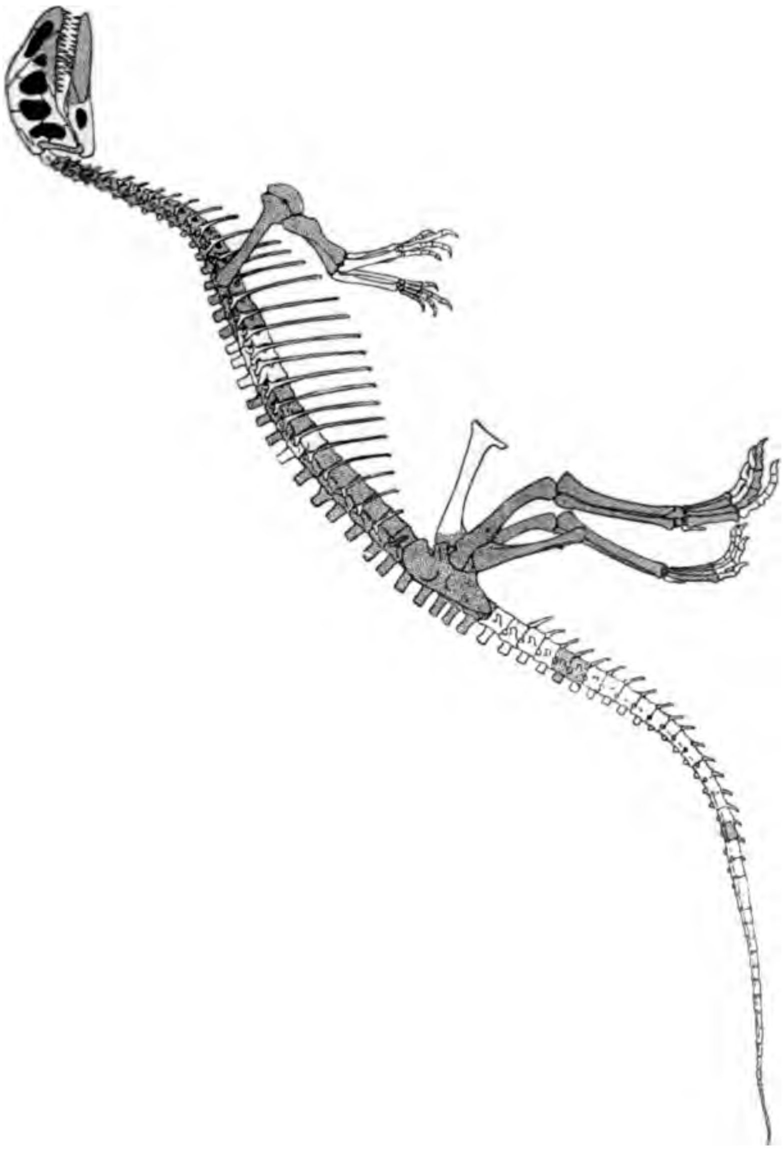
GENUS.	BIPEDAL.		QUADRUPEDAL.	
	Theropoda.	Orthopoda.	Sauropoda.	Orthopoda.
Ornithomimus	0·58 : 1	—	—	—
Nanosaurus	—	0·84 : 1	—	—
Hallopus	0·87 : 1	—	—	—
Anchisaurus	1·02 : 1	—	—	—
Trachodon	—	1·17 : 1	—	—
Megalosaurus	1·27 : 1	—	—	—
Cetiosaurus	—	—	1·32 : 1	—
Scelidosaurus	—	—	—	1·33 : 1
Apatosaurus	—	—	1·62 : 1	—
Stegosaurus	—	—	—	1·8 : 1

(Italics indicate Triassic or primitive forms.)

A more complete list, containing 24 genera, will be given in my later paper on *Streptospondylus*.

The proximally expanded fibula of *Streptospondylus* is conspicuous on account of its slender character, especially when compared with the robust form of the associated tibia. In consequence of this disproportion it seems much more slender than in either *Creosaurus*, *Allosaurus*, or the Triassic forms. It does not show any trace of distal expansion.

In the *astragalus*, which is applied firmly to, but not united with, the calcaneum, a well-developed ascending process is always present, but never reaches so high as in *Poikilopleuron*. As in the latter animal it is applied against a projection of the tibia. I wish



to refer to a former paper[1] for the phylogenetic value of the ascending process. In opposition to what is known of *Allosaurus* and *Megalosaurus*, there are in *Streptospondylus* in each foot four well-developed metatarsal bones, each bearing well-developed toes armed with claws. The claws show the carnivorous pattern.

With the superior crest of the ilium Mr. Parker's nearly complete *Streptospondylus* stood about 4 ft. 9 in. from the ground, and the Paris specimen may have been 6 feet in height; the total length of these two animals was probably 20 and 27 feet. *Megalosaurus*, we may assume, may have attained a maximum length of 30 feet.

Plate XV accompanying this notice gives a reconstruction of *Streptospondylus* as based on the study of Mr. J. Parker's fossil, and Miss A. B. Woodward has had the great kindness to make this drawing according to my directions. The large skull, the feeble but flexible neck, the weak anterior and powerful posterior limbs are well shown.

The principal differences of *Streptospondylus* and other Theropoda have already been pointed out in different parts of this paper; here I wish only to refer once more to the Sauropod-like build of the vertebral column. That the Sauropoda descended from bipedal Saurischia I intend to discuss upon some other occasion. The specific name of the only kind of *Streptospondylus* known till now is *Strept. Cuvieri* (H. v. Meyer); the horizons at which the genus occurs are the Callovian in France and the Oxford Clay at Oxford in England.

EXPLANATION OF PLATE XV.

Reconstruction of *Streptospondylus* (the shaded parts indicate the bones that are actually known).

II.—AN ACCOUNT OF SOME MARINE FOSSILS CONTAINED IN LIMESTONE NODULES FOUND ON THE MEKRAN BEACH, OFF THE ORMARA HEADLAND, BALUCHISTAN.

By R. BULLEN NEWTON, F.G.S.

(PLATES XVI AND XVII.)

THROUGH the kindness of Miss Caroline Birley, of Kensington, I have been privileged to examine a collection of fossil marine shells and other organisms in her possession, which occur in drab-coloured, gritty, and siliceous limestone nodules picked up on the beach off the Ormara Headland, facing the Mekran or Baluchistan coast, 130 miles west of Karachi, by Mr. F. W. Townsend, chief executive officer of the Submarine Telegraph Service in the North Indian Ocean.

So far as the present specimens demonstrate, the nodules vary in size from two to about four inches in diameter, many of them being as round as a ball with perfectly even surfaces, to which are sometimes attached parasitic forms of modern marine life, such as *Hippothoa*, etc. When split open with a hammer these nodules are invariably found to enclose a fossil of some kind, and most frequently a shell. The condition of the fossil is nearly always that of a natural cast exhibiting internal structures, whilst external features are often preserved in the concavity of the counterpart of the nodule, thus making it possible to obtain a fairly good restoration of the original shell by pressing into it some artists' wax or gutta percha.

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[1] Nopcsa, "Synopsis und Abstammung der Dinosaurier": Földtani Közlöny, Budapest, 1901.

A similar plan for obtaining structures was successfully adopted by Professor Ray Lankester when studying the marine shells and other organic remains found as casts in the celebrated sandstone nodules of the Suffolk Crag, known as the 'Box-Stones' (Quart. Journ. Geol. Soc., 1870, vol. xxvi, p. 499). And here it may be interesting to remark that the Suffolk 'Box-Stones' of all the fossiliferous nodules found in the different formations are perhaps the most convenient for comparison with those from the Mekran Coast, since they are most likely to be of an approximate geological age. They may be collected on the beach at Felixstow, after being washed out of the surrounding cliffs, where they occur *in situ*, or they may be obtained from the 'Coprolite-diggings' of the same neighbourhood. Fossils are much more rarely found in them than in the Mekran material, and many a nodule may be cracked open before an organism is discovered; the following genera have, however, been recognized: *Isocardia, Cardita, Glycymeris* (= *Pectunculus*), *Conus, Cassidaria, Pyrula, Turritella, Voluta, Mastodon*, etc.

Among the shell-remains of the Mekran nodules are *Cardium, Dosinia, Mactra, Arca, Dolium, Tugurium, Neptunea*, and *Lampusia*; the genera *Cardium* and *Tugurium* being of the most frequent occurrence. Besides these shells there is a Polyzoan encrusting the spire of *Neptunea* belonging to the genus *Membranipora*, which Mr. H. W. Burrows has kindly described for this paper. The Crustacea, represented by a crab's carapace and a species of *Balanus*, both of which are described by Dr. H. Woodward, F.R.S.; but no Echinoderms, Brachiopods, or Cephalopods were observed.

A very modern facies characterizes such a fauna as is here enumerated, the various genera being nearly all found in adjacent seas at the present day; the fauna also seems to indicate shore or shallow-water conditions of existence. But there are certain specific differences to be noted in this assemblage, which appear to suggest a relationship with Mio-Pliocene forms of the Mediterranean area and actual Indian Oceanic species. Moreover, Mr. Edgar Smith, of the British Museum (Nat. Hist.), and Mr. Cosmo Melvill, after an examination of this collection, are of opinion that the species are not represented in modern seas, although showing generic affinities with living mollusca.

With regard to the origin of the Mekran nodules, Mr. Townsend, the collector, seems to think that masses of the upper strata of the Ormara Headland break away from time to time, and so falling upon the beach become rolled and worn by the action of the sea; but it is much more probable that the nodules occur somewhere in the cliff *in situ*, and like the 'Box-Stones' of Felixstow reach the sea beach as rounded ball-like bodies without the intervention of subsequent marine agencies. The present collection comprises more than eighty examples of these nodules, and I am given to understand that they are to be met with in large numbers on the Mekran Coast, yet, notwithstanding their apparent common occurrence, there seem to be no published observations upon the subject. Among the few writers who have investigated the rocks of the Mekran Coast, Dr. W. T. Blanford's[1] name stands first. He regarded these cliff deposits as of post-Nummulitic age, and named them the 'Mekran Group,' describing as well their more or less flat-topped character and nearly horizontal bedding, as observed at Ras Malan, which is 2,000 feet high, Ormara, and Gwadar. In remarking upon the constitution of these beds he states that "The prevailing rock along the Makran Coast is a pale grey clay, more or less indurated, occasionally intersected by veins of gypsum, usually sandy and often calcareous, occurring in beds of great thickness. With this clay are interstratified bands of shelly limestone, calcareous grit, and sandstone, but these usually form but a small portion of the mass, although their greater hardness makes them conspicuous at the surface." An abundant marine fauna is said to characterize the various beds of the Mekran group with such genera as *Ostrea*, *Pecten*, *Arca*, *Cardium*, *Lucina*, *Cerithium*, *Turritella*, and *Natica*; besides Echinodermata, Corals, and Foraminifera (*Operculina*), but without Brachiopods or Cephalopods. Dr. Blanford further states that "the general facies of the Mekran fauna is utterly different from that of the Lower Tertiaries; the commonest and most characteristic fossils of the Nummulitics are Foraminifera, especially *Nummulites* and *Alveolina*; the most abundant shells in the Mekran Group are barnacles, oysters, and scallops. No junction of the two series has hitherto been observed, but it may be safely asserted that the Mekran Group is newer than the Nummulitics, for while the fauna of the latter appears to be nearly or entirely extinct, at all events in the shallow seas near the coast, several of the Mekran fossils appear identical with the species found living, in water of moderate depth, along the shores of Baluchistan and the Persian Gulf."

Capt. A. W. Stiffe,[2] who next visited the Mekran Coast, found the calcareous deposits to be almost entirely composed of marine organic remains, in parts distinct and perfect, forming a shelly breccia and passing into a more or less compact limestone. His fossils were submitted to Mr. Etheridge, who reported as follows:—"The shells appear to me to be of Miocene age, although all are mere casts, and therefore it is very unsafe to pronounce definitely as to their age. I cannot determine them to belong to the modern species of the Persian Gulf. The cast of *Conus*, *Cypræa*, and *Ostrea* are certainly not those of existing species; and the mass of shelly breccia containing *Dentalium, Cardita, Astarte, Venus, Trochus, Arca,* and *Tellina* I believe to be of more modern date, if not recent."

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[1] Records of the Geological Survey of India, 1872, vol. v, pp. 41-45.

[2] Quart. Journ. Geol. Soc., 1874, vol. xxx, pp. 50-53, with sketch-map of Mekran Coast.

In his classical work on "Eastern Persia" Dr. Blanford[1] again referred to the Mekran deposits as belonging to a "late Tertiary formation," inserting a list of determinations by Mr. Etheridge of a collection of fossils found by Dr. Day at Gwadar, which were considered as exhibiting "a very late facies, and may even be Pleistocene." This included *Dolium* sp., *Natica Lamarckiana* or a closely allied form, *Cerithium torulosum, Turritella* sp., *Fissurella* sp., *Jouanettia, Tellina edentula, Venus* sp. near *plicata* and *rugosa, Cytherea* sp. near *lyrata, Astarte* (?) sp. allied to *Circe corrugata, Diplodonta* sp., *Cardium,* two sp., one near *C. papyraceum, Chama* sp. near *C. isostoma, Arca,* four or five species, one of which is *A.* (*Parallelopipedum*) *tortuosa,* the others allied to various recent forms, *Pectunculus,* two species, one allied to *P. pectiniformis,* the other to *P. lividus, Pecten* somewhat resembling *P. pyxidatus, Ostrea* sp., *Temnopleurus,* two sp., *Eupsammia* sp. (coral), *Mæandrina* sp., *Operculina* sp.

A further allusion is made to the Mekran Group in Medlicott & Blanford's work on India,[2] with the remark that it "appears to be of later age than the Miocene Gaj Beds"; and, again, on the evidence of the Echinoidea (*Temnopleurus simplex,* Duncan & Sladen, etc.) found in these deposits Dr. P. M. Duncan and Mr. W. P. Sladen[3] came to the conclusion that the beds were younger than the Gaj Series (=Miocene) of India, and consequently might be regarded as Pliocene. In Mr. R. D. Oldham's edition of Medlicott & Blanford's "Manual," 1893, p. 316, it is stated that "The Mekran Group is of shallow-water marine origin and abounds in Mollusca, Echinoderms, etc., many of the species being apparently the same as living forms. The Echinoderms alone have as yet been examined in detail; they belong, without exception, to living genera, while most of the species are very closely allied to recent forms, and one species alone is doubtfully identical with a Gaj form. The general facies of the fauna is distinctly Pliocene." Lastly, Capt. Stiffe, in exhibiting "a fossil *Cardium* (?)" before the Geological Society in January, 1899, which had been found at the foot of the Cliffs of Ormara, stated that "the fossils in the clay are difficult to find, and probably are generally enclosed in nodules of the clay somewhat altered, as in this specimen." (Abstracts Proc. Geol. Soc. London, 1899, No. 701, pp. 31, 32.

With the exception of the extracts just quoted, and which deal exclusively with the fauna of the 'Mekran Group,' there are no monographs on the invertebrate fossils of the Tertiary formations of India which render much assistance in the determination of the specimens from the Mekran nodules. It may be as well, however, to refer briefly to the remaining literature which treats of the Tertiary invertebrates of other parts of India.

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[1] "Eastern Persia," 1876, vol. ii, pp. 462–465.

[2] "A Manual of the Geology of India," 1879, vol. ii, pp. 470, 471.

[3] "The Fossil Echinoidea from the Mekran Series (Pliocene) of the Coast of Biluchistan and of the Persian Gulf": Mem. Geol. Surv. India, Pal. Indica, 1886, *pp. 369–382,* pls. lvi–lviii.

One of the earliest papers is that by James de Carle Sowerby,[1] who determined Capt. Grant's Tertiary collections from Cutch as belonging to Nummulitic and later Tertiary horizons; this was succeeded in 1853 by D'Archiac & Haime's memoir[2] on the Nummulitic fossils of India, which unfortunately is not a reliable work, since Secondary and Tertiary specimens are mixed up together and regarded as coming from the same series of beds.

Then followed Stoliczka's[3] work on the Tertiary Crabs of Sind and Cutch; Duncan's[4] on the Fossil Corals of Sind; the Tertiary Echinoids of Western Sind being monographed by Duncan & Sladen[5] between 1882 and 1886; lastly, we have the very important treatise on the Miocene Fauna of Burma written by Dr. Fritz Noetling,[6] containing a large number of plates illustrative of the fossils (chiefly Mollusca) of that region, accompanied by a voluminous text.

In describing this fauna Dr. Noetling was able to trace, in a general way, its correlation with the Miocene of Java and the Miocene (Gajian) of Western India. He believed also that the present Indian Ocean fauna was directly derived from the Miocene faunas of India, Burma, Sumatra, and Java. Until more is known of the Tertiary Mollusca of Western India and its connection with the shells now living in the surrounding seas it would be premature to definitely state the age of the Mekran nodules, although we may assume, provisionally, that they are Pliocene and probably synchronous with the beds of the 'Mekran Group,' which Dr. Blanford first recognized as younger than either the Eocene or the Miocene periods. In support of this horizon we have the undoubted presence of a northern genus, *Neptunea*, associated with forms that belong to a torrid or warmer sea, an exactly similar phenomenon being known in the Pliocene beds of Europe, and that without any apparent disturbance of the deposits containing them. Further, in comparing this limited fauna of the Mekran nodules with either the Burmese Miocene fossils described by F. Noetling, or the specimens monographed by Dr. K. Martin from the Upper Tertiary beds of Java, there is insufficient evidence to prove a similarity in facies so as to suggest its correlation with the faunas of those two sets of deposits.

It would have been interesting to have compared the fossils of the present collection with the original specimens of the so-called

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[1] Appendix to Capt. Grant's "Memoir to illustrate a Geological Map of Cutch": Trans. Geol. Soc. London, 1840, ser. II, vol. v, pp. 289–329, pls. xxiv–xxvi.

[2] "Description des Animaux Fossiles du Group Nummulitique de l'Inde," 1853–1854, 2 vols., plates and text.

[3] "Observations on Fossil Crabs from Tertiary Deposits in Sind and Kutch": Mem. Soc. Geol. India, Pal. Indica, 1871, pp. 16, pls. v.

[4] "Sind Fossil Corals and Alcyonaria": ibid., 1880, pp. 110, pls. xxviii.

[5] "Tertiary Echinoidea of Western Sind": ibid., 1882–1886, text and plates.

[6] "Fauna of the Miocene Beds of Burma": ibid., new series, 1901, vol. i, pp. 378, pls. xxv.

'Mekran Group,' referred to in the foregoing literature, but, unfortunately, I have not been able to trace them either in the Museum of the Geological Society or in the British Museum, and I can only conclude that they may possibly be among the Indian Survey collections at Calcutta.

As it seems fairly apparent that no previous writers have called attention to the occurrence of these fossiliferous nodules, it is to be hoped that the present communication may be of sufficient interest to induce the authorities of the Indian Geological Survey to re-examine the rocks of the Mekran coast, with the view of discovering the exact position of the bed whence the nodules were derived, so that its relationship to the other deposits of the Mekran Group could be properly established.

DESCRIPTION OF THE SHELLS.

Lamellibranchia.

ARCA BLANFORDI, n.sp. (Pl. XVI, Fig. 5.)

Shell subquadrate, ventricose, arched, with an angulate, truncated, deep posterior side, the anterior area being rounded and oblique; umbones subcentral, rounded, strongly incurved; surface radiately ribbed and sulcated; ribs about 27, with depressed summits, angulated margins; surface transversely striated.

Dimensions.—Of moderate-sized right valve: umbono-ventral, 45; antero-posterior, 45; diameter of valve, 20 mm.

In its contour and general radiate appearance this species resembles *Arca rhombea* of Born, found off Ceylon and the Chinese seas, and which also occurs in the raised beach deposits of Karachi, India. It differs, however, in the valves being more rounded and arched, besides showing an absence of nodulous ornamentation on the ribs, which is especially developed on the anterior half of *A. rhombea.* The specimen figured is taken from a wax squeeze of a fairly well-preserved right valve found in one of the nodules, showing the more elevated region partially covered with costæ, the ventral area being stripped of the shell, thus exhibiting an impression of the extremely fine and close longitudinal striæ which adorn the internal surface of the valve, and which extend to within a short distance of the margin.

This shell is named in honour of Dr. W. T. Blanford, C.I.E., F.R.S., a former Director of the Geological Survey of India, and one of the earliest writers on the geology of the Mekran Coast.

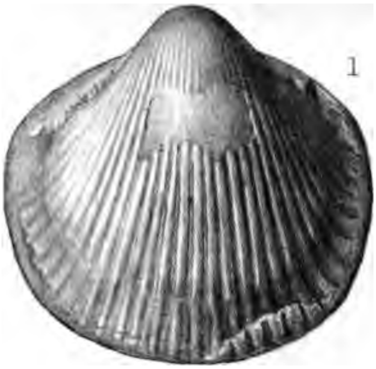
Examples.—Only three or four specimens in the collection.

MACTRA MEKRANENSIS, n.sp. (Pl. XVI, Figs. 6, 7.)

Shell subtriangularly ovate, cordiform, moderately convex, obtusely angulate posteriorly; umbones nearly central; sculpture consisting of narrow, depressed, smooth, concentric banding of equal width, each band separated by an extremely narrow sulcation.

Dimensions.—Right valve: umbono-ventral, 40; antero-posterior, 47; diameter, 10 mm.

The specimen referred to this form is represented by a right valve, *being* mainly an internal cast, yet retaining a small patch of original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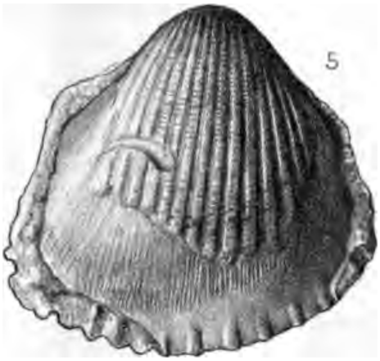
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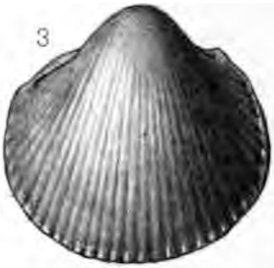
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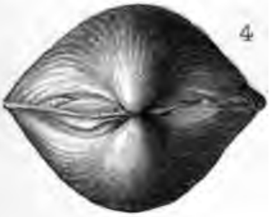
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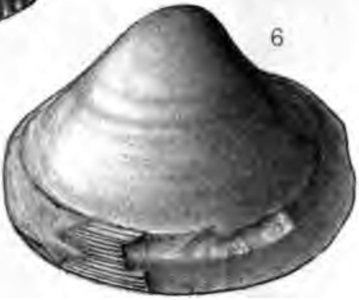
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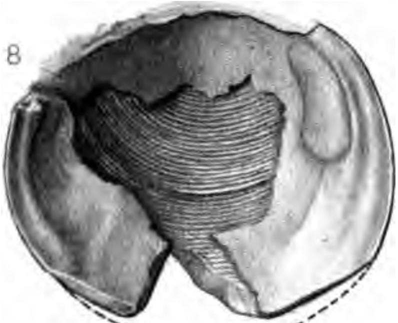
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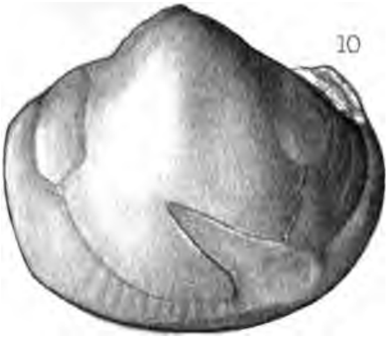
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G. M. Woodward del. et lith.

West, Newman imp

Tertiary Shells in nodules *from the* Mekran Coast.

shell structure on the postero-ventral region, which well illustrates the smooth, narrow-banded character of the sculpture. I have not been successful in discovering a shell which is suitable for comparison with this species, either among modern or fossil forms, its chief characters having reference to the triangularly oval shape and the regular concentric banding which ornaments the valve.

Example.—One specimen only in the collection.

Cardium Melvilli, n.sp. (Pl. XVI, Figs. 1–4.)

Shell globose, nearly equilateral, radiately costated; costæ about 37, depressed, angulated at the sides, separated by narrow, deep interspaces about one-half the width of the ribs (as seen near the ventral margin); umbones rounded, incurved, subcentral.

	Largest.	Smallest.
Dimensions.—Umbono-ventral	48 ...	35 mm.
Antero-posterior	48 ...	35 „
Diameter (closed valves) ...	38 ...	28 „

This is one of the most abundant shells found in the Mekran nodules, though always occurring as internal casts. Some original costal structure still remains on the ventral area of the larger specimen selected for illustration, showing that the ribs have rather wide flattened summits covered with delicately vaulted surface lineations, angulated sides, and divided by narrow sulcations which are closely and concavely striated within. In its well-arched and globular form and the great number of its ribs this species resembles *C. asiaticum* of Bruguière and *C. multispinosum* of Reeve, both living Pacific shells, though differing in the structural details of the costæ. In *C. asiaticum* the costæ are more elevated and narrower, besides being sharply lamelliform on the posterior region of the valves; and instead of lineations the surface exhibits a minutely granulate structure. The ribs in *C. multispinosum* are more rounded, besides being numerously spined with small projections. I know of no Miocene or Pliocene shell which suggests affinities with this species.

The species is named after Mr. J. Cosmo Melvill, M.A., F.L.S., who is one of our principal authorities on the modern conchology of the Persian Gulf.

Examples.—Numerously represented in the collection.

Dosinia sp. (Pl. XVI, Figs. 8–10.)

This shell is represented by a fractured left valve which exhibits both internal and external characters, the former including parts of the anterior and posterior surfaces, with complete margins, and giving good views of the adductor scar markings; through the broken surface of the centre of the valve the typical concentric lineations of this genus are well exposed. The other half of the nodule contains a natural cast of the valve showing impressions of the muscular markings and the pallial line with its conspicuously lanceolate, triangular sinus.

It is not possible to say more in connection with the specimen than that it somewhat resembles the European species *D. exoleta*, which is similarly orbicular, besides agreeing in general dimensions;

in sculpture characters, however, the Mekran specimen may possess more regular striations.

Dimensions.—Left valve; umbono-ventral, 50; antero-posterior, 50; diameter, 10 mm.

Examples.—There is only one specimen in the collection.

Gastropoda.

NEPTUNEA BURROWSI, n.sp. (Pl. XVII, Figs. 5–7.)

Shell turreted and fusiform, with a tricarinate body-whorl, which terminates anteriorly in a narrow straight canal. Upper surface of whorls oblique, slightly excavated, and furnished with rounded bicarinate margins; lower surface of whorls narrow, vertical, excavated, and unicarinate; shell structure closely, minutely, and spirally funiculate.

Dimensions.—Height, 37; diameter, 23 mm.

The test of this specimen is encircled throughout with regular narrow cord-like costellæ, separated by microscopically narrow sulcations, and crossed by fine and slightly curved striations of growth. There are ten costellæ on the oblique sutural region of the body-whorl, and six on the vertical surface of the penultimate whorl, these being margined above and below by a double row of more prominent ones, whilst the upper oblique region of the same whorl bears about eight costellæ. No varices or longitudinal costæ are present such as characterize the shells of the Muricidæ. There is no doubt that the Mekran shell bears a strong resemblance to some of the carinate forms of *Neptunea* which Searles Wood long ago described from the English Crag deposits as varieties of *Trophon antiquum*, Linnæus (see Mon. Pal. Soc., 1848, pl. v, figs. 1*a*, 1*b*), and which show a very similar funiculate shell-structure, i.e., var. *jugosum*. Moreover, the occurrence of *Neptunea* itself, which is more characteristic of boreal than warmer climates, in association with genera that belong essentially to warmer seas as are found in the Pliocene formations of Europe, would tend to prove that the Mekran nodules are of Pliocene age.

The specimen shows both cast and shell structure, the left of the spire being partially enveloped by a parasitic Polyzoan belonging to the genus *Membranipora*. The protoconch is unfortunately not preserved. I have named this interesting specimen after my friend Mr. H. W. Burrows, F.G.S., who for many years has studied the Crag fauna, and who is good enough on the present occasion to confirm my generic determination of this shell.

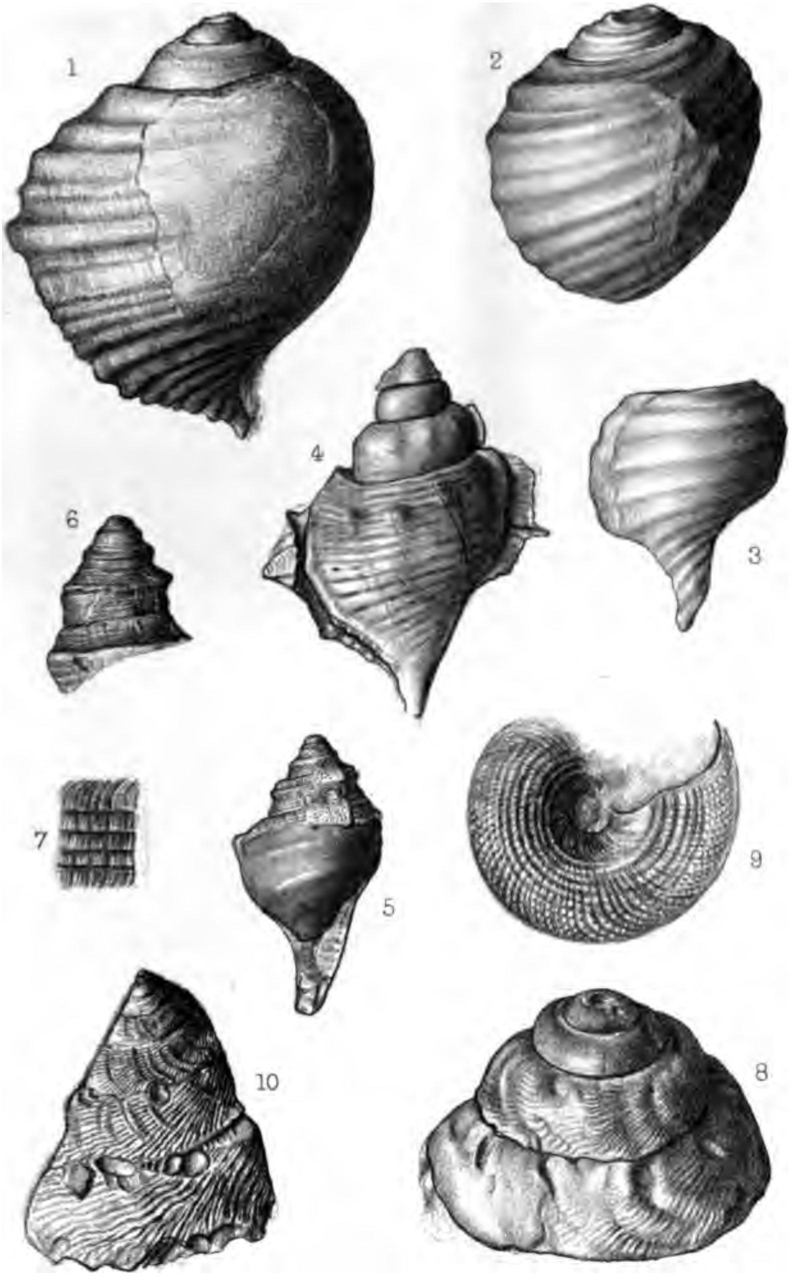
Examples.—One specimen only in the collection.

LAMPUSIA cf. AFFINIS, Deshayes. (Pl. XVII, Fig. 4.)

Triton affinis, Deshayes: "Expédition Scientifique de Morée, 1833, vol. iii (Zoologie), p. 188, pl. xxii, figs. 23, 24.

Triton corrugatum, Hörnes: Foss. Moll. Tertiaer-Beckens Wien, 1852, p. 206, pl. xx, figs. 1–4; *non* Lamarck.

There are several natural casts of this shell, all giving dorsal views and appearing to be related to *Triton affinis* of Deshayes,



G. M. Woodward del. et lith. West, Newman imp.

Tertiary Shells in nodules
from the Mekran Coast.

from the Upper Tertiaries of Greece, Italy, France, and Germany. Strong spiral costæ ornament the body-whorl, and a series of distant nodular tubercles surround the obtusely carinate margin, with evidence of a second obtuse tubercled margin below. The shell shows also the varixed labrum with a corresponding varix on the other side extending up the penultimate whorl. Except for their want of sharpness the Mekran casts resemble fairly closely those examples from the Vienna Basin Miocene deposits figured by Hörnes under the name of *T. corrugatum.*

Dimensions.—Height, 50; diameter, 33 mm.

Examples.—There are five very good specimens of this shell.

TUGURIUM MEKRANENSE, n.sp. (Pl. XVII, Figs. 8–10.)

Shell conical; whorls five or six, flattened, ornamented with numerous closely set, oblique, elevated, and rounded riblets, crossed by a series of equidistant, oblique, rather swollen growth ridges; suture distinct, and bearing agglutinations; base umbilicated, slightly concave, and furnished with a reticulate spiral sculpture.

Dimensions.—Height, 30; diameter, 50 mm.

This is one of the most abundant shells of the Mekran nodules. In sculpture it is very similar to *Xenophora crispa* of König, a species found in the Italian Pliocene, and which exists in the Mediterranean at the present day, although in that species the oblique striations of the upper surface of the whorls are coarser, more crenulated in structure, and considerably less regular in arrangement.

Again, *T. mekranense* is in no way related to *X. infundibulum* of Brocchi, also from the Pliocene of Italy, which is of larger size, imperforate, much excavated at the base and without basal reticulate sculpture; the upper surface of the whorls is also much more coarsely ornamented. On account of the umbilication and the fact that agglutinations take place at the suture this form is recognized under Fischer's name of *Tugurium.*

Examples.—Very numerously represented.

DOLIUM TOWNSENDI, n.sp. (Pl. XVII, Fig. 1.)

Shell thin, ovally globular, ventricose; volutions about five, penultimate and earlier whorls compressed, and showing obtuse median angulation, suture sunken, spire moderately elevated; body-whorl prominently sculptured with 15 or 16 rounded, ridge-like, spiral costæ of more regular occurrence below than above, and divided by depressed interspaces of variable widths which are sometimes faintly ridged in the centre; the postero-central rib is thicker and more important than the others.

Dimensions.—Height, 55; diameter, 47 mm.

The somewhat irregularly disposed costæ of this shell seem to separate it from other species. Beneath the rounded sutural margin of the body-whorl occurs a fairly wide excavated space followed by three prominent costæ and a fourth obscure one, all of which are separated by narrow interspaces; then follows the postero-central rib, which is stronger and thicker than the others. After the postero-central rib occurs a similar width of interspace as is found above, then succeed five rounded ribs extremely close together with very narrow interstices, these being succeeded by a series of five or six more prominent and more widely separated ribs which are nearly equidistant from each other.

This species is represented by only one shell, showing external dorsal characters. The vacant space on the body-whorl indicates a considerable absence of shell structure, although the sculpture details are well preserved in the neighbourhood of the aperture and the base. It appears to differ from other species, both fossil and recent, in the possession of a prominent postero-central rib and the general irregularity of the rib system.

The specific name of this shell is given as a slight acknowledgement to Mr. F. W. Townsend for having collected and sent to London so interesting a collection of specimens illustrative of the geology of the Mekran coast.

Examples.— One specimen only.

DOLIUM cf. HOCHSTETTERI, K. Martin. (Pl. XVII, Figs. 2, 3.)

Dolium Hochstetteri, K. Martin: "Die Tertiärschichten auf Java," 1879–80, p. 39, pl. vii, fig. 8.

It is interesting to find in this collection two examples of a *Dolium* which show a greater regularity of sculpture details than was observed in *D. Townsendi*. These possess a system of ribbing which strongly resembles what is present in Martin's *Dolium Hochstetteri* from the Upper Tertiaries of Java, and which approaches it also in general contour. The chief difference is probably the occasional presence in the Mekran specimens of an obscure median rib between the more prominent ones, which are not observable in Martin's figures. Among living shells this form of *Dolium* is related to *D. costatum* of Menke and Lamarck's *D. maculatum*, both well-known Indian Ocean species. The smaller of the two shells consists only of the body-whorl and the twisted anterior prolongation. The dorsal diameter of the larger specimen is 35 mm.

Examples.—Two specimens.

EXPLANATION OF PLATES.

Figures are drawn natural size, except a few magnifications which are introduced to illustrate shell structures.

PLATE XVI.

CARDIUM MELVILLI, n.sp.

FIG. 1.—Right valve, showing rib structure on ventral margin.
,, 2.—Magnified view of ribs, as preserved on Fig. 1.
,, 3. }
,, 4. } Views of a smaller specimen of the same species.

ARCA BLANFORDI, n.sp.

,, 5.—Right valve, showing costæ and striated internal surface at the fracture in the ventral region: drawn from wax impression of specimen.

MACTRA MEKRANENSIS, n.sp.

,, 6.—Right valve, with small patch of sculpture.
,, 7.—Magnified view of sculpture.

DOSINIA sp.

FIG. 8.—Left valve, showing partial sculpture and internal characters: drawn from a wax impression of specimen.
„ 9.—Magnified view of shell ornamentation.
„ 10.—Internal natural cast of same specimen, showing muscular scar impressions, pallial line, and lanceolate sinus.

PLATE XVII.

DOLIUM TOWNSENDI, n.sp.

FIG. 1.—Dorsal view of specimen.

DOLIUM cf. HOCHSTETTERI, Martin.

„ 2.—Dorsal aspect of the larger-sized specimen.
„ 3.—Smaller specimen, showing twisted columella.

LAMPUSIA cf. AFFINIS, Deshayes.

„ 4.—Specimen showing lateral varices.

NEPTUNEA BURROWSI, n.sp.

„ 5.—General view of specimen, showing anterior canal, with encrusting *Membranipora* on spire.
„ 6.—Another view of same specimen, showing shell structure.
„ 7.—Magnified view of funiculate sculpture.

TUGURIUM (XENOPHORA) MEKRANENSE, n.sp.

„ 8.—General view of specimen.
„ 9.—Basal view of another specimen, showing reticulate ornamentation.
„ 10.—Fragment of another specimen, showing external sculpturing and foreign attachments at the suture.

III.—NOTE ON A BRYOZOAN ATTACHED TO *NEPTUNEA* FOUND IN ONE OF THE MEKRAN NODULES.

By HENRY W. BURROWS, F.G.S.

MEMBRANIPORA LACROIXI (V. Audouin).

Flustra Lacroixii, V. Audouin: in J. C. Savigny's "Description de l'E'gypte," Hist. Nat. Polypes, Planches, 1817, vol. ii, pl. x, fig. 9; Explication des Planches, 1826, vol. i, pt. 4, p. 240.
Conopeum reticulum, J. E. Gray: List British Animals British Museum, pt. i, Radiated Animals, 1848, p. 108.
Membranipora Lacroixii, G. Busk: Cat. Marine Polyzoa British Museum, pt. ii, 1854, p. 60, pl. lxix, figs. 1-3.
Biflustra Lacroixii, F. A. Smitt: pt. ii of "Floridan Bryozoa," Kongl. Svenska Vetensk.-Akad. Handl. (Stockholm), 1873, vol. xi, No. 4, p. 18, pl. iv, figs. 85–88.

For other references and synonyms, see Miss E. C. Jelly's "A Synonymic Catalogue of the Recent Marine Bryozoa, including Fossil Synonyms," 1889, pp. 162–164.

DIAGNOSIS.—*Zoarium*, adnate.

Zoœcia, oval or ovato-quadrangular, often elongated; area (usually) coincident with the whole of the front of the cell (front 'wall' membranous in the living state). Margins thick, strongly crenulate.

Oœcia, none.

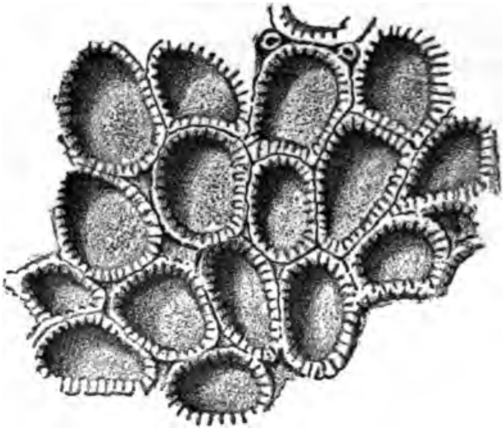
Avicularia (?), small, subcircular or roundedly triangular, situate in the anterior angles of the space between the zoœcial walls, sparsely developed.

The colony under description is attached to the apical whorls of a *Neptunea*, closely allied to the Crag *N. jugosa* (S. V. Wood), and which was found enclosed in one of the Mekran nodules.

The zooecia are rather distorted and crowded together as they accommodate themselves to the sutures and ridges of the mollusc on which they have grown. The mature zooecia measure about 0·20 by 0·33 mm., and are almost quadrangular, with slightly rounded angles.

This species appears to be referable to *M. Lacroixii*, as figured by Busk in the British Museum Catalogue, the most apparent difference being that the cell-walls are relatively thicker; this, however, is more noticeable in the earlier zooecia—the later formed and typical cells have thinner walls.

The synonymy of this species is rather involved, but reference need only here be made to the most important.



Membranipora Lacroixi (V. Audouin). Enlarged 45 times. Attached to apical whorls of *Neptunea Jugosa*, found enclosed in nodule from Mekran Coast.

Busk,[1] in the "Crag Polyzoa" (p. 31), refers *Lacroixii* (in part) to *Savartii*, Audouin.

Pergens[2] regards *M. reticulum*, *M. Lacroixii*, and *M. Savartii* as synonymous.

Later writers have considered *M. Savartii* to be a distinct species, and have included in its synonymy *Biflustra delicatula* of the Crag.

Waters,[3] in his memoir on the Membraniporidæ, points out that the 'rosette-plates' of *M. Lacroixii* and *M. Savartii* are quite different.

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[1] G. Busk, A Monograph of the Fossil Polyzoa of the Crag: Palæontographical Society, 1859.

[2] Ed. Pergens, "Pliocäne Bryozoën von Rhodos": Ann. k.k. nat. Hofmuseums (Wien), 1887, vol. ii, p. 14.

[3] A. W. Waters, "Observations on Membraniporidæ": Journ. Linn. Soc., Zool., 1898, vol. xxvi, p. 679.

Miss Jelly (following Pergens) regards *M. Lacroixii* of Audouin and Busk as referable to *M. reticulum* (Linné).

Membranipora Lacroixii has a wide geographical and geological range, as the following records will show :—

Geographical distribution. British (Hincks), Mediterranean (Savigny), Florida (Smitt), St. Lawrence (Whiteaves), New Zealand (Waters).

Fossil. Coralline and Red Crag (Busk and Bell); Miocene and Pliocene of Austria and Hungary (Manzoni and Reuss); Pliocene of Italy (Manzoni, Waters, Neviani) and of Rhodes (Pergens); Post-Pliocene (Dawson).

NOTE.—The specimen is not well preserved, and the characters, in part, are somewhat obscure. The figure has been drawn from a photograph, the detail being restored.

IV.—NOTE ON A FOSSIL CRAB AND A GROUP OF *BALANI* DISCOVERED IN CONCRETIONS ON THE BEACH AT ORMARA HEADLAND, MEKRAN COAST.

By HENRY WOODWARD, LL.D., F.R.S., V.P.Z.S., F.G.S.

HAVING been desired by my friend Miss Caroline Birley to examine two Crustaceans in nodules from the Mekran Coast—part of a much larger series, mostly enclosing fossil shells, described by Mr. R. B. Newton, F.G.S. (see ante, pp. 293–303)—I gladly comply with the request to add a note thereon to his paper.

The first concretion, when broken open, displays the dorsal aspect in impression and counterpart of a small crab, 5½ cm. broad by 3 cm. deep, having one long, slender, forcipated chela, imperfectly preserved, measuring nearly 5 cm. in length; and part of one of the fifth posterior pair of feet, adapted for swimming, showing it to have been near to the family PORTUNIDÆ, to which our common shore-crabs of the genus *Portunus* belong. None of these, however, can be satisfactorily compared with the fossil crab from Ormara, which is certainly referable to another genus.

In *Portunus* the carapace is only slightly broader than deep, the latero-anterior margin having four or five serrations of equal size; there is no prominent costal spine. In our fossil the carapace is compressed vertically and greatly expanded laterally, being armed at each angle with a prominent costal spine, while a series probably of eight (?) lesser serrations (the points of which are broken off in our specimen) fringe the regularly arched convexity of the latero-anterior border from the orbit to the costal spine, below which the postero-lateral margin is concave and the posterior border straight.

These features, added to the details of the carapace itself, enable us to refer it to the genus *Neptunus* of De Haan (see "Fauna Japonica").

In describing two new species from the Eocene of Kutch and Sind, the late Dr. Ferdinand Stoliczka wrote :[1] "The species of *Neptunus* are easily distinguished from the allied genera, *Scylla*, *Lupa*, and *Acheolus*, by having the last or costal spine considerably longer than the remaining eight spines of the antero-lateral margin."

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[1] See Memoirs Geol. Surv. India, Palæontologia Indica: "On some Tertiary Crabs from Sind and Kutch" (1871), p. 3.

The recent species are tolerably numerous; *Neptunus hastatus*, Linn., inhabits the Mediterranean, but for the most part these forms occur within the tropics, as in the West Indies, the coasts of Brazil, the Pacific, and the seas of India and Asia.

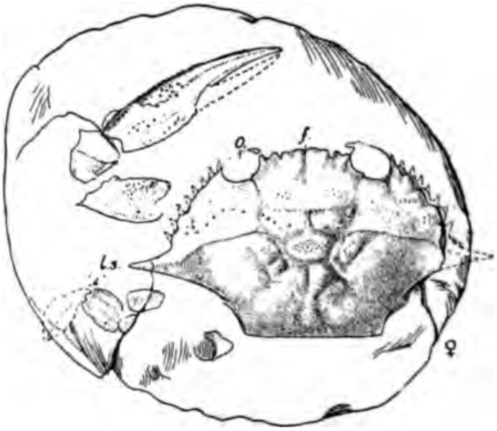

Fig. 1.—*Neptunus Arabicus*, H. Woodw., sp. nov. Newer Tertiary, Mekran Coast. Preserved in a nodular concretion which has been split open, disclosing the fossil crab in its interior. (The dotted lines indicate probable restoration of broken parts.)

Family, Portunidæ; genus, *Neptunus*, De Haan.

The late Professor Alphonse Milne-Edwards[1] described six Tertiary species, one from France, one from Sardinia, four from Northern Italy, and Herr Max Blanckenhorn has added one from the Miocene of Sinai,[2] viz.:—

Neptunus Monspeliensis, A. M.-Edw.	Eocene:	Montpellier, France.
„ *Larteti*, A. M.-Edw.	„	Paris and Milan Museums.
„ *Vicentinus*, A. M.-Edw.	„	Turin, North Italy.
„ *arcuatus*, A. M.-Edw.	„	Vicentin, „
„ *granulatus*, A. M.-Edw.[2]	Tertiary:	Island of Sardinia.
„ *incertus*, A. M.-Edw.	„	Vicentin, North Italy.

To these must be added—

Neptunus Wynneanus, Stoliczka.	„	Kutch, India.
„ *Sindensis*, Stoliczka.	„	Sind, India.

and the present specimen, which we may venture to name—

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[1] In his "Histoire des Crustacés Podophthalmaires Fossiles," tom. i, 1861-5, pp. 100–118, pls. iii–vii: Ann. Sci. nat., 4e ser., Zool., t. xiv.

[2] *Neptunus granulatus*, A. M.-Edw., is recorded in a list of fossils as occurring in the Miocene of Sinai. See Max Blanckenhorn, "Neues zur Geologie und Palaontologie Ægyptens," iii, Das Miocän: Zeitschr. Deutsch. Geol. Ges., 1901.

NEPTUNUS ARABICUS, H. Woodw., sp. nov. See Text-figure (Fig. 1).

Pliocene (?): Mekran Coast.

Description. — Carapace broader than long (5½ cm. by 3 cm.), semicircular in front; rostral border not prominently produced, 14 mm. wide, having a notch and a slight median depression in the centre; this divides two low, broad, undulated prominences, each 4 mm. wide, marking the position of the first or inner pair of antennæ; these are separated by a notch (1 mm. deep) from the next pair of double serrations, 3 mm. wide, covering the second or outer pair of antennæ; they complete the rostrum and form the inner orbital spine; the orbits are large, oval, 7 mm. wide by 5 deep; the border marked by one fissure above and apparently none beneath; then follows the outer orbital spine (probably succeeded by seven other more or less equal serrations), as indicated by dotted lines in Fig. 1, ending with the strongly developed costal spine (*l.s.*), which completes the latero-anterior angle of the carapace. The postero-lateral border curves inwards and contracts rapidly from 5½ cm. broad at the costal spine to 2 cm. behind the articulation of the fifth pair of legs. The specimen was evidently a female; therefore the posterior border of the carapace is considerably wider than would be that of a male of the same species.

Gastric region 18 mm. broad, marked by a median longitudinal depression in front, and a transverse, slightly raised line of minute pustules across the centre, separating the epigastric and protogastric from the mesogastric lobes; the metagastric and the urogastric lobes are continuous with one another, and form a slightly raised, shield-like median space produced in front into a slender, spine-like ridge 4 mm. long, which terminates at the median epigastric furrow. The hepatic region is not subdivided; it is rather depressed anteriorly, and is separated from the gastric region by a slight furrow and from the branchial region by a curved, well-defined, raised ridge, which extends from the gastric furrow to the extremity of the lateral or costal spine. The cardiac region occupies a central position behind the gastric region, being about 6 mm. broad in the centre, and is subdivided anteriorly into two well-marked triangular lobes by a median depression, ending in a pillar-like median lobe behind. The branchial region is tumid, marked by a slight double swelling next the gastric and cardiac border, where a somewhat deep furrow is formed.

The surface generally is finely granulated, with small patches of coarser granules on the proto- and metagastric lobes and on the adjacent branchial prominence, while a few minute, linear-wise tubercles mark the mesogastric and hepatic lobes.

The propodos of the fore-limb is 3 cm. long and 1 cm. broad, the surface being covered with coarse, rounded granules and scored longitudinally by two furrows which converge at the extremity of the fixed chela; the moveable claw (dactylus) is not seen; it must have been 15 mm. in length. The carpus was 8 mm. long: the meros 15 mm. long by 7 mm. broad. The basal joints are concealed by matrix.

The last or posterior pair of walking limbs in the genera

Portunus, *Scylla*, and *Neptunus* are specially modified to serve as natatory appendages, their joints being flattened and expanded for swimming, and are carried above the carapace when not used in natation, the three other pairs of simple feet serving as walking and running appendages. Only a fragmentary remnant of one of these swimming feet is preserved on the left side behind the large costal spine.

De Haan, in Siebold's "Fauna Japonica,"[1] distinguishes three equivalent subgenera, *Neptunus*, *Amphitrite*, and *Pontus*. They are all characterized by the large size of the costal spine. The subdivisions are based upon the form of the third endopodite joint of the outer maxillary feet. In *Neptunus* this joint is longer than broad, with the lower inner angle conspicuously produced, and with the upper hinder edge rounded. In *Amphitrite* the upper hinder edge of the third endopodite is considerably produced and also rounded. In *Pontus* the same joint is said to be square.

Amphitrite was accepted by Dana,[2] but united with *Neptunus* by Alphonse Milne-Edwards.[3] But the character relating to the form of the third joint seems to be subordinate.

Stoliczka had already observed (Crust. from Kutch and Sind, op. cit., p. 3) that "it is remarkable to find the *Amphitrite* form already represented in fossil species from Kutch" (as noticeable in his *N. Wynneanus*); he adds, however, that the name *Amphitrite* had been already used by Müller in 1771 as a generic name, and therefore it cannot be reinstated, but must remain a synonym of *Neptunus*.

As all the species already recorded in a fossil state have been obtained from beds older than the formation at Ormara yielding the fossiliferous concretions,[4] I have compared our crab with De Haan's figures and descriptions of recent (living) species from the Indian Ocean and the Sea of Japan. The first of these figured by him is *Neptunus pelagicus*, probably the largest and most powerful swimming-crab living, with a carapace twice as wide as it is deep, with long and powerful costal spines, a regularly arched front armed with eight equal serrations on each side; the powerful chelate fore-arms are considerably longer than the extreme breadth of the carapace. It is, however, in De Haan's subgenus "*Amphitrite*" that species are found which most closely resemble our fossil form.

In *Neptunus* (*Amphitrite*) *hastatoides*, Fabr. (De Haan, tab. i, fig. 4), the costal spines are equal to half the breadth of the carapace; two short spines are also present, one at each postero-lateral angle of the carapace behind the insertion of the fifth pair of swimming feet.

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[1] Crustacea, by W. de Haan, 1850, Leyden, 4to, with 70 plates.

[2] J. D. Dana: "Classification and Distribution of Crustacea," 4to, 1853, p. 1424. Fam. IV, Portunidæ. 1, Lupinæ. Genera: *Scylla*, De Haan; *Lupa*, Lh.; *Amphitrite*, De Haan; etc.

[3] A. Milne-Edwards, Hist. Crust. Podoph. Foss., 1861–5, tome i, p. 100, gives genus *Neptunus* (synonymy: *Cancer*, pars, Linné; *Portunus*, Fabr.; *Lupa*, pars, Leach; etc.). *Neptunus*, *Pontus*, et *Amphitrite*, pars, De Haan; *Lupa* et *Amphitrite*, pars, Dana: Expl. Exped. Crust.

[4] *See* Mr. Newton's remarks ante, pp. 296 and 300.

In ***Neptunus*** (***Amphitrite***) ***gladiator***, Fabr. (De Haan, tab. i, fig. 5), the general features resemble our Mekran crab, but the regions of the carapace do not correspond in detail; the costal spines, although not so long as in *A. hastatoides*, are not straight but curved somewhat forward; the frontal border between the orbits has six distinct pointed teeth, not four rounded double prominences as in our specimen. The branchial furrow in *A. gladiator* also is much more arcuate.

On the whole, I find that *Neptunus* (*Amphitrite*) *tenuipes*, De Haan (tab. i, fig. 3), agrees most nearly with our Mekran crab. The costal spines are not dissimilar in length; the regions of the carapace resemble the fossil in most particulars. We are unable to compare the maxillipeds in our specimen with De Haan's figures, as we have only the dorsal aspect of the carapace exposed in the nodule.

The frontal region does not exhibit quite the same rounded and paired undulations as in our fossil crab, nor are the costal spines of equal proportion.

I prefer, therefore, to designate the fossil form from Mekran by the trivial name of *N. Arabicus*, in allusion to the Arabian Sea, which washes the shores of the Ormara Headland, where these concretions were collected.

Before quitting this subject, I may refer to another allied fossil crab with long costal spines, described by me as *Rhachiosoma bispinosa*, of which a fine series of specimens was obtained by the late Messrs. C. J. A. Meyer and Caleb Evans from the Lower Eocene of Portsmouth Dockyard (and figured and described by me in the Quart. Journ. Geol. Soc., 1870, vol. xxvii, pp. 90–92, pl. iv, figs. 3, 5; and 1873, vol. xxix, pp. 25–31, double-plate i, figs. 1–6). These specimems are of extreme interest in connection with the evolution of this group of the Brachyura, as they present a more generalized form, combining the character of the Neptunidæ in the development of the strong costal spine, not produced in the Portunidæ, but agreeing with the latter in having only five spines or serrations on the latero-anterior border instead of nine, as in *Neptunus* (see op. cit., 1873, vol. xxix, pl. i, in which the latest and most perfect examples are figured). These beautiful specimens from the Lower Eocene are preserved in the Museum of the Geological Society, Burlington House, a bequest from the late Mr. Caleb Evans, F.G.S.

Should other and more perfect specimens from the Mekran Coast be met with, and prove to have only five serrations on the latero-anterior margin, then this form might be generically separated from *Neptunus* and form, with *Rhachiosoma*, another subfamily intermediate between the Portunidæ and the Neptunidæ, as combining some of the characters found in both these groups.

NOTE ON *BALANUS TINTINNABULUM*, Linn.

Darwin's var. 7, *coccopoma*: "Cirripedia: Balanidæ," Ray Society, 1854, pp. 194–196, pl. i, figs. 1, 2.

The *Balani* from Ormara Headland, Mekran Coast, are contained in two nodules, one of which exhibits two or three examples only, the other a group of ten very well preserved individuals clustered together of which a figure is given in the text below (Fig. 2). They have been most successfully developed from the hard concretionary matrix by Mr. Richard Hall, the Museum Formatori, and the only regret is that none of the opercular valves have been preserved, or, [illegible] I may say, have not been exposed to view, during the process of removing the matrix. (In specimens of *Balanus concavus* and other species from the Coralline Crag of Suffolk, I have frequently recovered the perfect set of opercular valves from the interior of the body-chamber, and, but for the hardness of the matrix, they might almost certainly be found within the interior of these fossil 'acorn shells' of the Mekran Coast also.)

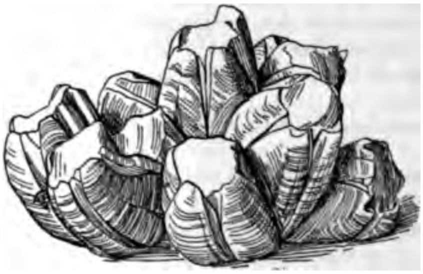

Fig. 2.—Group of ten individual Balani developed out of the interior of a concretionary nodule from the cliffs on the seashore, Ormara Headland, Mekran Coast. Referred to *Balanus tintinnabulum*, Linn., var. *coccopoma*, Darwin.

The orifice of the shell (if complete) would have been enclosed by these moveable valves, i.e. by a pair of tergal and two scutal valves, upon the characters of which the species could at once have been determined. We have, then, only the shell-walls, composed of a carina, a rostrum, two rostro-lateral and two carino-lateral compartments, which, with their interlocking radii and alæ, enclose the body-chamber on every side, the lower surface being protected by the *basis* (not visible), which varies greatly in different genera, as indeed do also the walls of the shell itself.

After a careful comparison of the specimen with Charles Darwin's beautiful plates and descriptions of the sessile forms of Cirripedia (Balanidæ, Ray Society, 1854), I am led to conclude that the nearest species to our fossil is *Balanus tintinnabulum*, Linn., and of its many varieties probably Darwin's (var. 7) *coccopoma* best represents it, its form being globulo-conical, orifice small, walls rounded, generally smooth, thick (colour *x*). Some of the compartments show, in addition to lines of growth, fine wavy raised plicæ or parallel striæ, but for the most part lines of growth are alone visible.

V.—THE RECENT GEOLOGICAL HISTORY OF THE BALTIC.
PART I: THE LITORINA SEA.

By Sir H. H. HOWORTH, F.R.S., F.G.S.

THE recent history of the Baltic involves problems of great interest and importance, and promises to afford considerable help in solving the mysteries of the later geological changes in Western Europe. It is therefore worth a closer study than has been extended to it in this country. Perhaps I may be permitted to condense in the GEOLOGICAL MAGAZINE what has been written about it in late years by the Scandinavian geologists, and to add some inferences of my own. I am especially indebted to De Geers and Munthe, the latter of whom has written quite an ideal monograph on one section of the story in the Bulletin of the Geological Institution of the University of Upsala, vol. ii.[1]

The most conspicuous feature of the Baltic compared with other seas directly communicating with the ocean, and in which it resembles a lake, is the slight salinity of its water, while its upper waters differ in this respect very sensibly from its lower ones.

"In the Gulf of Bothnia, at the time when the river-flow is greatest, the surface water is so little salt as to be quite drinkable, its specific gravity being as low as 1·004. It is said to contain at Christmas, when its fresh-water supplies are largely frozen, six times as much salt as at Midsummer, showing that when the river supply is at its lowest its place is taken by a reflux of salt water from the outside ocean. . . . . At Kiel, if the direction of the prevalent winds in Autumn be such as to maintain a strong surface out-current, and consequently a very strong inward under-current, as happens in some years, the maximum of salinity will present itself at that season, otherwise Meyer found that the specific gravity of the water at Kiel ranges from about 1·0182 in Summer to 1·0142 in Winter, the latter showing about half the quantity of salt in sea water." (Encyc. Brit., iii, 297, article *Baltic*.)

The degree of salinity of the waters of the Baltic decreases very much, as we should expect, as we leave the ocean and get nearer to its inner recesses. The following is a useful table compiled by Munthe from the best official sources, and showing the average percentage of salt at different places in the Western Baltic going eastwards. The figures are taken from actual observations.

Skagens Rev	2·96	Darsser Ort	1·06
Laesö Trindel...	2·49	Gjedsör Rev	1·01
Kobbergrunden	2·32	Lappegrunden	1·41
Anholts Knob...	2·10	Northern part of Oresund	1·25
Schulz's Grund	1·93	Copenhagen	1·21
Samsö Belt	1·55	Drogden	1·08
Kiel...	1·60	Lohme (Rügen)	0·81
Poël, off Wismar	1·24	Christiansö, N. of Bornholm	0·78
Warnemünde...	1·18	Hela (West Prussia) ...	0·72

Continuing the investigation further east, for which we have not the same precision of testimony, Munthe, from considerations dependent on the distribution of the mollusca, has calculated the position of the isohalinic line, or line of equal saltness, for the percentage of ·07, ·06, ·05, ·04, and ·03 respectively, at various points of the Eastern Baltic from the island of Gotland to the upper reaches of the Bothnian Gulf.

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[1] "Preliminary Report on the Physical Geography of the Litorina Sea," pp. 1-38.

These figures show that between the Cattegat, where the ocean is close by, and the upper part of the Bothnian Gulf the degree of salinity in the Baltic decreases gradually from 2·96 per cent. to ·03 per cent. This distribution of salt in its waters has naturally had a great effect upon the marine molluscan fauna of the Baltic, and also has affected their size and caused them to become distorted. To this interesting issue we will now turn. For the purpose of investigation the Baltic may be divided into two sections by a line drawn a little to the east of the island of Bornholm, and we will at present limit ourselves to that section of the sea (much its larger portion) lying to the east of such a line.

The poverty of the living molluscan fauna of this part of the Baltic is phenomenal. That fauna is, in fact, limited to the following shells:—

(1) *Tellina balthica*, var. *a* and *b*. The form found in the Baltic is the original type. It also occurs in the Southampton Water and in the Orwell estuary. Löven deemed it a degenerate form of *T. solidula*, due to the brackish conditions in which it lives. Jeffreys says it is a hardy mollusc, accommodating itself to all kinds of temperature and all kinds of water, from nearly fresh to the saltest.

(2) *Mytilus edulis* (a dwarf form).

(3) *Cardium edule* (also a dwarf form).

(4) *Mya arenaria.*

(5) *Balanus improvisus.*

(6) *Paludinella balthica* (a distorted form; it was formerly called *Hydrobia ulvæ*). Under the latter name Jeffreys calls attention to the distinction of this species from the rest of the *Hydrobiæ* in that it loves brackish water, in which it in fact lives in the Thames. Elsewhere he says that it is never found out of the reach of the tide.[1]

(7) *Neritina fluviatilis*, of which Munthe says that it is found at Landskrona in water with 1·2 per cent. of salt, that it lives in slow rivers, streams, and lakes, but that a dwarf variety has been described by Nilsson inhabiting the shores of the Baltic and adhering to seaweeds and stones, sometimes at a distance from the mouth of any river, and living in company with the common mussel and a few other decidedly marine shells (id., p. 54). In this case the dwarfing has doubtless been caused by the water being too salt instead of too fresh for the mollusc to adequately thrive.

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[1] In regard to this mollusc a note of Jeffreys is curious. It seems it has been found in salt springs and marshes in the Ain and Jura, and he thinks this may indicate there an ancient estuary of the Rhone (Brit. Con., v, pp. 208–9).

In addition to these molluscs we may mention as also living in the Eastern Baltic the Bryozoan ***Membranipora pilosa*** (var. ***membranacea***). Among the molluscs here enumerated two are very recent additions to the Baltic fauna, and have never occurred in the raised beaches or shell-beds. These are ***Mya arenaria*** (the 'clam' of the American writers) and ***Balanus improvisus***. The ***Mya*** is now quite a common shell in the Eastern Baltic, and Lyell as long ago as 1835 noted the remarkable fact that it was not found in any of the shell-beds (Phil. Trans., 1835, pt. 1). It has no doubt migrated from the Cattegat, and it is singular that it did not do so before, for, as G. Jeffreys says, "it is found living in sand at low water, chiefly in estuaries where there is an admixture of fresh water with the sea." He says further, "its capability of living in brackish and even fresh water is well known" (Brit. Conch., iii, 65, 66). The second recent addition is the acorn-shell, known as ***Balanus improvisus***, which has occurred at Reval, Helsingfors, and in the Gulf of Finland, and may have been introduced on ships.

Putting aside these two recently imported forms, which are irrelevant to the purpose of this paper, the other species above mentioned are all found in the shell-beds and recent deposits of the coasts of the Eastern Baltic.

In regard to the effect which the slight salinity of the waters of that sea has had on the size of the shells, Munthe has shown how its mussel (which is true also of its cockle) diminishes rapidly as the water becomes fresher. Thus he gives the normal length of the mussel in different parts of the Baltic in the following table:—

	mm.
Kiel	110·0
Bay of Travemünde	84·0
Between Moen and Falsterbo	64·0
Rügen	52·4
Gotland (probably too little)	c. 40·0
Stockholm Archipelago	43·0
Åland	c. 35·0
Ulfön, the innermost known Swedish locality	22·5
Stänggrund, the innermost known Finnish locality	21·0

It seems clear that the addition of fresh water to salt in more than certain proportions inevitably dwarfs or distorts the shells, and the deformity is to be found wherever marine molluscs are living under brackish conditions. It is due probably partially to the want of adequate food for the mollusc itself, and partially to the absence in the brackish water of sufficient adequate materials to build up the shell.

Let us now turn from the recent shells in the Eastern Baltic to those found in the later shell-beds on its shores.

The first person to recognize these shell-beds was Magnus Bromell, who speaks of an accumulation of *Mytilus* and *Cardium* shells near Stockholm (Lith. Suec., specimen secundum, Upsala, 1727, p. 58 et seq.).

Linnæus, in the first edition of his "Systema Naturæ," 1735, refers to the ***Mytilus*** accumulations in Helsingland as "humus conchacea Helsingica," and he and others afterwards mentioned similar remains in other parts of Sweden.

Lyell, in his well-known paper in the Phil. Trans. for 1835, pt. 1, enumerated the shells he had found in these beds, which (says Munthe) is still a complete list so far as the Stockholm district is concerned. Of *Mytilus* he had also found the small white *flustra*, now so commonly attached to them, in the Baltic. He also names the Gasteropod *Neritina fluviatilis*, which lives in fresh and brackish waters. He lastly pointed out that the above-named fossil mollusca are smaller than, and in some cases actually dwarf forms of, those now living in the ocean, thus agreeing with the living Baltic shells.

The enclosed character of the Baltic, which gives it its brackish quality, is an old physical feature of the sea, and it is not strange that in the accumulations of estuarine mud and the raised shell-beds on its shores we should be able to trace this characteristic of the sea back in time to a considerable distance. When we examine these beds, which consist partly of shell deposits and partly of estuarine black clays containing molluscs, we shall find that the same features which mark the living Baltic fauna have prevailed there for a considerable time. We have a similar scanty fauna, and we have also a series of shells which are more or less stunted or deformed. It is nevertheless important to remember—and the fact was not recognized by the older writers—that in these respects the living shells considerably exaggerate the conditions prevailing in the shell-beds. In the first place the latter, although poor in species, are richer than they would be if they were being deposited at this moment. In addition to *Tellina balthica*, in two forms which grade into each other as now, *Mytilus edulis*, *Cardium edule*, *Paludinella balthica*, and the Bryozoan *Membranipora pilosa*, we have in these beds two species of *Litorina*, a *Rissoa*, and a worm *Spirorbis borealis*.

In regard to four of the species mentioned as found in the later raised shell-beds of the coasts of the Eastern Baltic, it is an important fact that they no longer live there. These are *Litorina litorea*, *Litorina rudis* (since shown to belong to the sub-species *tenebrosa*), a *Rissoa* (probably a small race of *Rissoa membranacea*), *Scrobicularia piperata*, and the worm *Spirorbis borealis*. None of these shells are now found living east of the island of Bornholm, and it was concluded by Löven that the reason is that the Eastern Baltic has become less salt and in fact too fresh to admit of their living there, for they continue to thrive in the Western Baltic.

This conclusion was made a virtual certainty by the investigations of Munthe, who has shown not only that the shells last named have been completely excluded from the living fauna of the Eastern Baltic, but that the habitat of all the other marine species now living there has been driven further south and nearer to the supply of salt water, since the shells in the shell-beds were living. He has further shown that in the interval each of these shells has moved its habitat further south in a regular order and corresponding to its capacity for tolerating a more or less mixture of fresh water with salt.

Thus, in the black clays at Neder Kalix, at the very head of the Bothnian Gulf, there have occurred *Tellina balthica*, which is now found living as far north as Umea; *Mytilus edulis*, whose northern living range is Ulfön, south of Örnsköldsvik ; *Cardium edule* and *Hydrobia ulvæ* (*Paludinella balthica*), which occur living at Kristinestad in Finland; and *Litorina rudis*, var. *tenebrosa*, which does not now extend beyond Bornholm. *Litorina litorea*, which is found in the raised beds north of Hudiksvall, and which Löven and Erdmann thought no longer lived in the Baltic, is still found living around the isle of Rugen.

Rissoa membranacea (var.), which now only reaches the meridian of Zealand in Denmark, and therefore the Western Baltic, has been found in the shell-beds of the Åland Islands and on the opposite coast of Sweden. *Scrobicularia piperata*, which is not known living further than Wismar Bay, has occurred in the shell-beds of North Gotland. *Spirorbis borealis*, not now found further than about Ystad, where Munthe says he found it on *Mytilus*, has been found in the shell-beds of Gotland and Upsala.

Membranipora pilosa, var. *membranacea*, whose furthest living limits are Kristinestad in Finland, and Ulfön, between Hernösand and Örnsköldsvik, in Sweden, has been found fossil by Munthe as far north as Skellefteå in company with *Mytilus* and *Tellina*, and *with the leaf of a spruce fir.*

The disappearance of *Litorinæ* and *Rissoæ* from the island of Gotland was coincident with the introduction of *Limnæa ovata* into the Baltic fauna. Löven found it in some cases associated in the shell-beds with the *Litorinas*, and he accordingly separated these *Litorina* beds into two horizons, one marked by the presence of *Limnæa* and the other by its absence. This invasion of a mollusc (the *Limnæa*), which can only tolerate a certain amount of brackishness in the water (Munthe says it lives in water with $1\frac{1}{15}$ parts of salt at Malmö), is another proof of the change in regard to salinity which has occurred in the Eastern Baltic since the later beds on its borders were deposited. This is again supported by the change which has taken place in the shells themselves, no doubt due to the same cause. Thus Lindström found that the specimens of *Cardium edule* found in the shell-beds of the Island of Gotland were larger than those now living there.

Again, Munthe says that mussels of about 52 mm. in length, corresponding to those now found at Rügen, are met with in the raised shell-beds as far north as the Skellefteä district of Sweden; and he concludes that as the fauna of these *Litorina* beds, from the most northerly part of the Bothnian Gulf down to Gotland, corresponds most nearly to that of the present Baltic between Bornholm and Warnemünde, the hydrographic character, especially in regard to salt of the Baltic *Litorina* sea, corresponded to that now existing in the district in question, which has a proportion of salt at the surface of 0·78–1·2 per cent. Elsewhere he says: "The fauna that inhabited the Baltic in the *Litorina* time from the most northerly point of the Bothnian Gulf down to Gotland corresponds most nearly to the present fauna of the comparatively limited area of the same sea that lies between Bornholm and Warnemünde" (op. cit., pp. 5, 6).

Although it is clear, therefore, that the water of the Baltic has been growing more brackish, it is quite clear also that in the *Litorina* time it was also brackish but not to the same extent. This follows from the fact that the shells found in these beds are smaller, in some cases very much smaller, than those of the same species found in the open sea, a fact which Nathorst has shown graphically by giving us side by side figures of the Baltic *Cardium* and a *Litorina* and the same shells from the open sea. It follows also from the occurrence of two brackish-water shells in these beds—the *Paludinella balthica*, which is not a salt but a brackish-water shell, and the *Neritina fluviatilis*.

Having established that the waters of the Eastern Baltic have become less salt and more brackish in the most recent geological period, i.e. that now current, the next question that arises is as to the cause for this change. One thing is clear enough, namely, that when the *Litorinas* were living in the Eastern Baltic it covered a larger space and contained a larger quantity of water. This is plain from the raised beds in which the *Litorinas* occur, which must then have been submerged.

The true *Litorina* sea extended as far as the Sound, for the beds found virtually at the sea-level at Malmö contain *Cardiums* and *Litorinas* like those in the Baltic. The same is the case with the other side of the Sound, where at Rördam the beds occur with *Cardium edule*, *Mytilus edulis*, *Tellina balthica*, *Litorina litorea*, and *Nassa reticulata* (Nathorst, Sveriges Geologi, 277).

When we go northwards into the district of the Mälar Sea we find these shell-beds at a much higher level. Thus, Erdmann in 1868 gave a list of some of the places where clay with similar shells had occurred in the district of the Mälar Sea, with their height above the sea and their distance from the Baltic (Sver. Geol. Undersökning, i, 42) :—

	Height. Feet.		Distance from the Baltic. Myriametres.
North of Örebro	130	...	12–15
South of Toflasjön, near Arboga ...	100	...	10–12
South of Kungsör	70	...	9
Hasslö, east of Westeräs	40	...	9
Enköping	30–50	...	7
North of Husby Church, in Nykopingslan	140	...	6–7
Upsala, Slottsbacken	140	...	5
Södertelge	40–90	...	3

Erdmann tells us that at Nyäker, north-east of Upsala, and at Skattmansö, a few miles north of Enköping, there have also occurred in the black clays remains of the bullhead (*Cottus scorpius*), a characteristic fish of the present Baltic. Nathorst tells us that the variety of the perch (*Perca fluviatilis*) known as the Baltic perch has been found with *Mytilus* at Stureplan, near Stockholm (see Sveriges Geologi, 271); a grey seal (*Halichœrus gryphus*) was found in Gotland, while a skeleton of the whale *Eschrichtius robustus* was found in the same beds in 1859 at Gräsön in Roslagen (id.). The black clay resembles the buttery clay which underlies the flat levels of the lands round the Wash in East Anglia.

Erdmann tells us that this black clay is often found intercalated with the beds of gravel and rolled stones which form the covering mantle of the äsar, and in some cases this mantle is so full of shells as to be formed almost entirely of them. These banks of shells often occur without clay, and interbedded among the upper layers of the gravels and sands, and sometimes with clay which underlies them or with the so-called äkerlera which covers them. The shells contained in them are the same as those in the black clays. Erdmann gives a figure of the äs of Enköping, where these shell-beds occur on a great scale, intercalated with beds of gravel, stones, and sand. At one place the shell-bed, several feet thick, consists almost entirely of comminuted shells of *Mytilus edulis* and *Tellina balthica*. The shell-beds are separated by beds of gravel or barren clay and sand. Erdmann says that in a great cutting through this äs at Enköping there is found the typical black earth containing shells of *Mytilus edulis*. The epidermis of the *Mytilus* is singularly well preserved in many cases when the shells themselves have entirely disappeared (id., pp. 96, 97). After the work just cited was written Erdmann recognized these beds as far as Linde at the head of a lake of that name 130 miles west of Stockholm, and to a height of 230 feet above the sea-level, which, Lyell argues, shows that the Baltic has been separated for a long time, as now, from the ocean ("Principles," 12th ed., p. 194).

Again, in 1873, Gumælius reported beds with shells of *M. edulis* and *T. balthica*, ranging as high as 250 feet above the sea-level, at Bondsio, near Hernösand, at the mouth of the Angerman River, and at Avoka, near the frontier of Medelpad. Munthe apparently found these beds at Hernösand at a height of 330 feet above the sea ("Sommarkursernai, Upsala," 1893, p. 16). Gumælius mentions *T. balthica*, *H. ulvæ*, a *L. rudis* (since shown to be *rudis*), and *N. fluviatilis* as found there (G. F. i Stock. För., i, 233–4). Hisinger found the same beds at Djekneboda in Westerbotten; Freidholm, at Neder Kalix at the head of the Bothnian Gulf, at the height of at least 110 feet, and Högbom, at Löfänger, and Rickleä, from 80 to 100 feet above the sea-level. These contained fragments of *Mytilus*, and more sparsely *Tellina balthica*.

At Alnön, in 62° 28′ N. lat., Munthe found the shell-beds at the height of 77 metres, at Örnsköldsvik at 60 metres, and at Neder Kalix at 51 metres (De Geers, G. F. i Stock. För., xii, 104).

On the borders of Finland and its islands similar beds have also been found. They were first described from the Åland Islands as far back as 1767 by Tuneld, and since by Holmberg and others. Eichwald described similar deposits in a fine sand along the coast near Helsingfors, and especially mentions *Mytilus edulis* and *Tellina balthica*. both small, *Paludina balthica* (i.e. *Hydrobia ulvæ*), and *Nerita fluviatilis* as found in it. He mentions similar deposits from Vöra Kyrka in the province of Vasa, on the east of the Bothnian Gulf, as also affording fragments of *Mytilus* edulis.

Nordenskiöld and Nylander, in their monograph on Finnish shells mention the occurrence of shell-beds of this time in the Åland Archipelago, e.g., at Söderjarnno, near Nadendal (near Abo), on Ingo Island, at Kiälkö, near Helsingfors, and at Kampen; and Schmidt has described the presence of the beds with this fauna on the shores of the Eastern Baltic. He tells us that they are found entirely covering the äsar at Karris in the island of Oesel, and also those on the Isle of Worms, while the äsar in the interior of Esthland are free from them. Similar beds, however, are found in that province, along which were once apparently inlets and gulfs of the sea up to a height of 60 feet. They cover a strip of country about 10 versts in width, and at Fickel form a tongue extending further inland. At Awaste we apparently have the old boundary of the sea forming a low terrace, and here blocks of granite are found mixed with shells of *Cardium edule*. Similar beds with the same fauna exist in the islands of Nuckö, Worms, and Dago. In North Esthland similar deposits wash old gulfs projecting into the land such as Fähna and what Schmidt calls "die ganze Baltischporter Halbinsel." They occur in long mounds of rolled gravel, sand, etc., and contain *Litorina litorea* (which is no longer found there) and other species of shells found in the neighbouring Baltic. These mounds, with the same marine fauna, are found as far east as Narva, to the east of which there are no such deposits, and this is also the eastern limit of living marine shells in the Gulf of Finland. Such marine shells, either living or fossil, also entirely fail us in the neighbourhood of Lakes Onega and Ladoga, whose Crustaceans and fish have been sometimes quoted as affording evidence of a former communication between the Gulf of Finland and the White Sea (Schmidt, Z.D.G.G., xxxvi, 266, etc.).

The island of Gotland has been fruitful in discoveries of the *Litorina* period. Lindstrom found in beds there, besides the ordinary Baltic shells, *Rissoa labiosa* (?), *Litorina rudis* (var. *tenebrosa*), and others, *Spirorbis borealis*, and the shells of *Cardium edule*, larger in size than those now living; and Munthe reports from the same horizon remains of the seal *Halichœrus gryphus*. Munthe mentions *Litorina* deposits in the north of Gotland at a height of 27 metres, and Lindstrom names them north of Wisby at 24 metres.

De Geers, Munthe, and Nathorst have given admirable maps showing the extent to which the *Litorina* sea, when at its full extent, encroached upon what is now land in the Eastern Baltic. This encroachment involved a considerable strip round the whole east coast of Sweden, beginning at Karlskrona and including the whole of the Gulfs of Bothnia and Finland and the coasts of Esthland with the islands off it, and the similar coasts of the island of Gotland. This invasion of the present land surface was especially remarkable in the district round the Mälar Sea and round the coast of Finland. It means that the general depth of the water over the area of the Central and Northern Baltic was considerably greater in the *Litorina* sea than it is now.

This, again, accounts most reasonably for the greater salinity of at sea in ancient times than now. Lomberg has analyzed the nditions of the present currents of salt and fresh water in that a with considerable lucidity, and makes it dependent on the esent submarine banks and reefs which cross that sea and which terfere with the nether currents, conditions which would of course ot be present in the same degree when the general depth of the ater was greater. Thus he says: "The southern sill and the rrowing between Saltholm and Scania cause the brackish currents om the Baltic to reach right to the bottom; but as the Sound idens again these currents broaden and thin out so that their fects do not stretch so deep. Thus the bank between Malmö and ltholm forms a complete barrier against the marine forms, the uthern end of the Sound is occupied by a brackish-water fauna, and e limit between this and the deeper salt-water fauna gradually ses nearer the surface as it approaches the northern end of the und" (Lomberg, Meddelanden främ Kong. Landb., pp. 43, 44, ans. by Bather, *Nat. Science*, xv, 269). Munthe has applied the me form of reasoning to the conditions of the Baltic in the *Litorina* me. Thus he says: "The condition of things was of course most vourable for the transfer of salt water from the Cattegat to the altic at the stage when the land subsidence in the *Litorina* time d reached its maximum . . . . Remembering that the Baltic sin's bottom at the *Litorina* time lay comparatively deep below e surface of the ocean, we can see that, especially at the stage of eatest subsidence, the salt currents from the Cattegat must have en able to force their way much more easily than at present, en across the bars, hidden under water, that are to be found in e district both at the boundary between the Bothnian Gulf and the altic and in North Quarken. As the results of the Ekman expedition 1877 show, these hidden bars, lying now at a depth of less than) metres, hinder to an appreciable extent the influx of salter der-currents. This cannot have been to the same extent the se in the *Litorina* time, for the bars then lay at a considerably eater depth, viz., at a depth of about 90 and 130 metres spectively." This seems to be a quite rational and adequate planation of the decreasing salinity of the Baltic.

In concluding this paper may I add a word about another matter some importance. In recent years strong efforts have been made some, and notably by Professor Suess, to show that the alleged anges of level in sea and land round the Baltic has been due to shifting of the water-level due to aberrant influences, and not to y alteration in the earth's crust.

The evidence of the *Litorina* beds seems quite inconsistent with is conclusion, for they are neither at the same level nor do they lminate in height in a regular gradation in any direction; but on e contrary they culminate to a point, i.e. the neighbourhood of ernösand, in the Central Baltic, from which they fall away both rth and south. This is not all.

The fact that the level at which the so-called *Litorina* deposits cur increases considerably as we proceed from the Baltic towards the.

Dovrefelds is further good evidence that the elevation was not uniform, but must have diminished as we travel eastward from the high mountains towards the coast. Munthe's researches prove, as he says, that the isobases for the *Litorina* deposits show a gradual rise in their level from the Stockholm district inwards towards the central districts (id., p. 11). Again, he speaks of the upheaval of the land being greatest the further one goes towards the central part of Scandinavia. This is in accordance with the conclusions of De Geers. The greatest elevation, in fact, occurs between lats. 62 and 64, from which it diminishes both northwards and southwards.

These facts seem conclusive that the shell-beds testify to an actual alteration in level of the solid crust of the earth, and not merely to a moving envelope of water.

VI.—SOME EXAMPLES OF JOINTING IN CHALK.

By CLAUDE H. B. EPPS, B.A., The College, Winchester.

(PLATE XVIII.)

THE structures described in this note occur in a large chalk-pit close to Hensting Farm, by Owlesbury, near Winchester. The east face is vertical, about forty feet high; near the bottom, along a well-marked bed of the Chalk, some deposits of gravel and clay are exposed at varying distances from each other; three of these are small, two rather larger. On the south face there is a similar deposit near the top of the pit, but this is inaccessible, and no special structure can be seen in the surrounding Chalk owing to its conversion into subsoil.

Of the two larger deposits one is almost hidden by débris, but the other shows some points of interest. It consists of a ridge of sand and clay, projecting obliquely from the face of the cliff for a distance of some eight feet, the surrounding chalk having been removed; a little digging shows that it is a true 'fossil watercourse,' not merely fallen material. In section it is roughly circular, about two feet in diameter; the greater part consists of a dark brown sandy clay showing current-bedding, with somewhat fine gravel, the grains of which are not much rounded above, and pieces of chalk and a few flints which have fallen from the roof of the channel into the stream.

The Chalk through which the underground stream once ran is fairly hard and homogeneous, consisting of the *Belemnitella quadrata* zone; it dips 5° S., but the bedding is otherwise undisturbed. Several bands of flint occur higher up in the pit, but low down there are few.

Within a distance of seven or eight feet from the deposit the Chalk shows strikingly regular joints, which form three distinct sets. The first set consists of roughly cylindrical joints, co-axial with the deposit; the second of radiating planes, perpendicular to the first set; and the third of planes transverse to the axis of the deposit. As the face of the pit is oblique to the former course of the stream the first set appear as portions of ellipses, unless the observer is

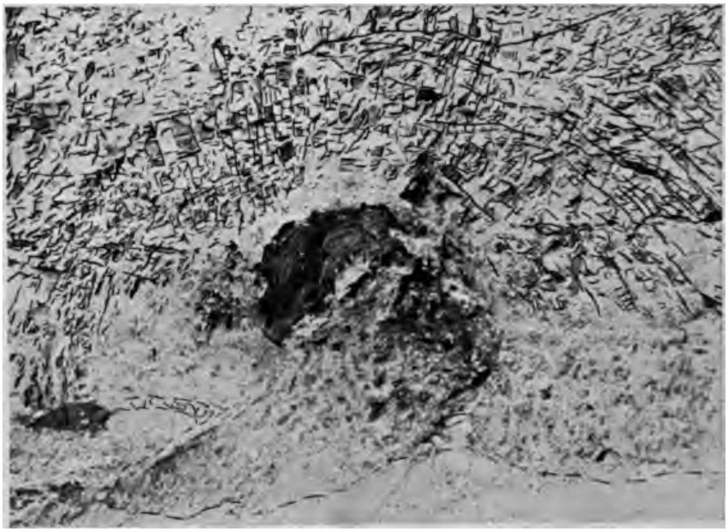

FIG. 1.

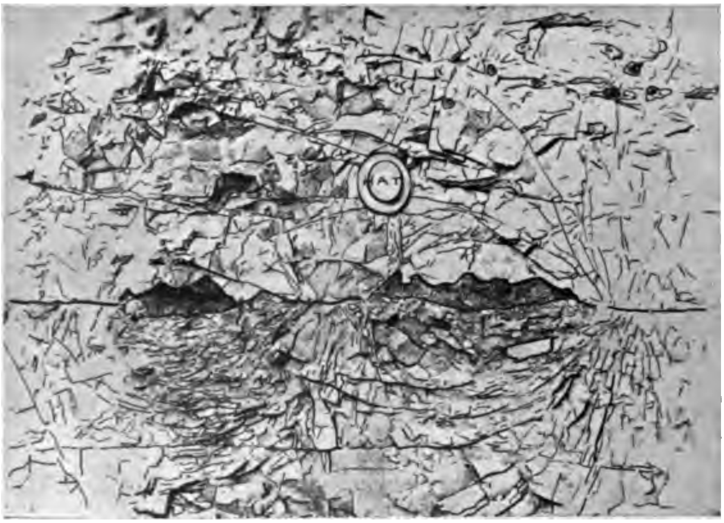

FIG. 2.

Radial jointing observed in relation to ancient watercourses in the *Chalk*, Owlesbury, near Winchester, by Mr. C. H. B. Epps.

aced on the axis of the deposit, when the true shape can be seen uch better (see Plate XVIII, Fig. 1).

The photograph accompanying this note was taken from this cial point of view; the ridge of sand and clay is, of course, much reshortened. (The height of section shown is about fifteen feet.) wing to the uniformity of colour of the chalk and the fact that ost of the joint faces were equally illuminated, it was necessary, order to get a clear diagram, to go over every line visible with aterproof ink, afterwards partially bleaching the print; at the isk of making the diagram confused every line visible on the print a good light was marked, whatever its direction.

The cylindrical joints can be fairly easily seen; the radial joints re best seen to the left of the central line; the faces formed by the ransverse joints are directed towards the camera, so that the joints hemselves are not visible.

A simple explanation of the formation of the three sets of joints is rovided by the fact that chalk is soluble. After the channel of the tream became choked by deposit, and the waters were forced to run lsewhere (possibly through the other small channels visible on the ame level), the chalk by long-continued solution slowly contracted, while beyond a certain point the gravel and clay would not contract. Under these conditions it is clear that three sets of joints would be ormed round a solid rod-like axis if the contracting material were omogeneous.

Plate XVIII, Fig. 2, shows the structure of the chalk round wo of the smaller deposits which occur on the same level in the it; this photograph has been treated in the same way as the first. A similar explanation of this case seems to be possible, though its pplication is not quite so easy. Owing to the band-like shape of he deposits the chief joints radiate from points at the ends of the ands, looping from one point to the other, thus producing a figure omewhat like the lines of force of a simple magnet.

VII.—THE GEOLOGICAL PHYSICS OF THE SHALLOW SEAS.

By A. R. HUNT, F.L.S., F.G.S.

SINCE the year 1871 I have been much impressed with the interest and importance of one of the byways of science, he problem of the Geological Physics of the Shallow Seas. Recent discoveries in raised beaches have brought this subject again to the front, and the object of the present paper is to plead for urther inquiry by specialists.

I may briefly mention my own now antiquated papers, viz., 'Notes on Torbay" (Trans. Dev. Assoc., 1878); "The Formation of Ripple-mark" (Proc. Roy. Soc., 1882); "The Action of Waves on Sea Beaches and Sea Bottoms" (Roy. Dublin Soc., 1885); and 'On the Influence of Wave-currents on the Fauna inhabiting Shallow Seas" (Journ. Linn. Soc., 1884). With the exception of the Dublin paper, the MSS. were, as a matter of fact, perused by eminent mathematicians, who kindly guarded me against any conflict between observation and theory.

It is doubtful, and indeed improbable, that anyone has carefully read all those papers, as geologists might be deterred by the technical zoology, the zoologists by the technical geology, and physicists by both. The fact was that the complex subject required the attention of first-rate specialists, and it was utterly beyond my powers to do justice to it, or even to sufficiently impress scientific men with its real interest and importance.

So far as I was personally concerned my efforts were fully acknowledged: by election in 1879 to the General Committee of the British Association, and in 1884 to the Linnean Society. But, notwithstanding this, the subject has been rather persistently ignored, and a month scarcely passes without some crusted old fallacy being repeated in print. It is, however, absolutely useless to contradict the errors in detail.

As the question of raised beaches is essentially one of marine geological physics, I am, for the reasons given above, much interested in the problems suggested by the new evidence, entirely apart from any personal opinions.

A raised beach is obviously an ancient water margin; and, according to the character of its deposits, so must have been its related submarine slope seawards. As a rule the ancient slope, or sea-bottom, has been subsequently raised and eroded to a much lower level, and were the land again lowered to its ancient beach-level, the conditions would be quite different, and the waves would merely remove every vestige of beach-deposit from the old remnant of a beach or foreshore platform. But in Ireland, we now learn, thanks to the researches of Messrs. Wright & Muff, that the present recent shingle occasionally rests on an ancient ice-scored beach platform or its equivalent, a state of things one might well have deemed impossible. However, the fact must be faced. As a raised beach is, after all, a beach, to understand it thoroughly the student must be intimate with modern beaches. In fact, a raised beach student should be geologist, conchologist, and marine engineer. Whether that combination at present exists I am not aware, but its advantage was exemplified in the case of the late Daniel Pidgeon, who from his knowledge of beaches and conchology, and being also an engineer, though not a marine engineer, at once discerned the unbeachlike character of a portion of the Hope's Nose beach-deposits. At present beaches are being keenly studied by marine engineers, with a view to sea defence works. Most of the details of the forms and depths of drowned and silted valleys are in the offices of railway engineers, in connection with their bridges and viaducts. The present depths of estuaries and submerged plateaux are in the large-scale marine charts, while the raised beaches are known only to geologists, who, however, often pay too little attention to the shell fragments in the beach deposits. Even my friend Mr. Ussher, who knows well-nigh every rock exposure in South Devon, tells us of a consolidated bed of mminuted shells lying on one of the low-level beach platforms, d passes on without further remark.[1] Comminuted shells are ften quite enough for a conchologist, and might settle many nportant questions. In fact, one of the present difficulties is to ccount for shells with a southern range on Devonshire raised eaches of the same levels as the Irish glacial beach-platforms. ut that is perhaps a comparative trifle compared to others.

By a curious coincidence my friend Mr. Lamplugh published is account of the Bridlington pre-Glacial beach in a British ssociation Report in 1888, and I published my own raised each work in the Trans. Dev. Assoc. in the same year. Now r. Lamplugh's beach, so far as is known, contains only a few rdinary present-day shells and the mammalian cave fauna, with e addition of hippopotamus. These deposits rest on a chalk each platform, and are covered with glacial deposits, indicating reat cold. Thus the beach platform and the beach itself need not epresent so cold a climate as that which followed. But in the rish beaches described by Messrs. Wright & Muff, almost exactly n the level of Mr. Lamplugh's beach, we have, much further south, he rock platform itself ice-scored, affording no accommodation or hippopotami. If both these beaches are 'pre-some-glacial' as has been neatly said by a great geologist), have we to exalt hese superficial deposits to the 8,000 feet altitude of ice and snow nd of aerial erosion of the most virulent type? Then when these eaches have descended again to the water-level in good preservation ust we give them a further dip? These acrobatic oscillations, hich geologists summon to their aid as lightly as they would call hansom cab, absolutely confound the beach-student.

If we transfer the Bridlington beach mammalian fauna to Kent's avern, substituting beaver for hippopotamus, we find their horizon o be the cave earth and upper stalagmite, during the earlier part of hich period England must have been continental to admit of the dvent of the animals. As we find remains of the cave mammalia n beach platforms both at Bridlington and the Gower Peninsula, he question arises whether the beach platforms were cut before ngland was continental and before the arrival of the mammalia, or fter the continental stage, and when the land and sea had returned o their former levels. In the former case the platforms and beaches ould not be of the same age, whereas in the latter case they might e. The immense difference in character between the old crystalline nd the new granular stalagmites in Kent's Cavern is best explained y difference of climate. Under glacial conditions the formation f stalagmite would be continuous even if intermittent[2]; though his may seem an Hibernianism. Under present conditions there ould be alternate deposition and solution. Water charged with ime and carbonic acid entering the cave in summer would dissolve arbonate of lime, but in the winter would deposit it. The rystalline stalagmite indicates conditions dissimilar from the present, and may well also indicate glacial conditions. It is extremely difficult to adjust the evidence of beaches, raised beaches, caves, and other geological phenomena; but were it not for such uncertainties geology would not possess the interest which it certainly has.

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[1] Memoirs Geol. Surv., No. 356, p. 68.

[2] E.g. the second-hand of a watch.

There are two periods of indefinite duration concerning which the Kent's Cavern deposits are silent, viz., the time between the crystalline stalagmite and the advent of the hyæna, and the time between the close of the granular stalagmite (synchronous with the disappearance of hyæna) and Neolithic and modern times. There is also a good deal of inferential evidence from the molluscs found in the cavern, including *Venus chione* and full-sized *Pecten maximus*, but induction from those premises would most certainly be scouted as merely speculative. More 's the pity! One thing is pretty sure, and that is that neither the Torbay raised beaches nor Kent's Cavern have been submerged since the era of the cave earth and of the cave mammalia. At any rate, the evidence seems to preclude that possibility.

I have no desire to press my opinions on anyone, nor to contest the opinions of anyone, but I have tried to keep these geological physical problems alive in the hope that someone, some day, will work them out. They are certainly worth the attempt.

For more than thirty years I have seen from my house what is perhaps the most intricate assemblage of beaches, raised beaches, platforms, shelves, shore ledges, foreshores, submerged forests, and drowned valleys that can be seen from any one spot in England. I cannot forget them, for I cannot look out of the window without having them actually or mentally before me. In the middle distance is the limestone plateau of Daddy Hole Plain, a true plane, not a peneplain; beyond the bay with its submerged plain of many square miles, as flat as a billiard table, is the platform or terrace of Berry Head, overhanging the shore ledge and raised beach near the old Naval Hospital. This terrace can be traced by the eye as far as Galmpton Common, where it serves for golf-links; and beyond it is seen the drowned and partly silted-up valley of the Dart. Following the line of the coast we cross the filled-up valley at Goodrington, and passing the level and truncated headlands of Roundham Head, Livermead Head, and Corbons Head, we leave the submerged forest at Torre Abbey sands and the terrace of the Waldon Hill, to reach the filled-up submerged valley of Fleet Street, Torquay. With the mind's eye we can see, through the intervening hills, the raised beaches at Hope's Nose and the Thatcher Rock, and the higher platform of the Babbicombe Downs, also useful as golf-links. By the same means we can visualize the absolutely level 'continental shelf' of the bottom of Torbay, running out at right angles to, and falling rapidly into, the gentle seaward slope of the Great West Bay. We also mentally take note of Kent's Cavern and of the several caverns at Brixham. Further inland we have the higher lands in which aerial erosion has *obscured* any traces there may be of marine erosion.

So far as my experience goes, there is no Englishman who takes lively interest in all these phenomena, but perhaps some day . Nansen will look at them in the light of his profound quaintance with the more fully developed marine sculpturing Scandinavia.

The Torquay marine platforms and shelves, drowned valleys, l submerged forests are duplicated remarkably on the coast of lloway, and curiously enough the headland corresponding to rry Head is called the Burrow Head !

If we examine an ordinary map of the South of England we ll note that the Lizard Head, Prawle Point, and Portland Bill nearly in line, the Prawle Point projecting, with deep bays th east and west of it; both the Lizard and the Prawle ving stoutly, and apparently almost perfectly, resisted the attacks the waves. We see in the rocky foreshore at the Prawle, nearly quarter of a mile from high-water mark to the furthest reef covered at low tide, how hard the fight has been. This four ndred yards tidal platform cut in the hard metamorphic rocks of e Prawle district is a very significant phenomenon. If we follow e line of coast eastward we find the great resistance collapses when e metamorphic rocks are passed, but minor resistances will be ticed at Froward Point, near Dartmouth, and in the massive nestones of Berry Head. Then resistance is for a time entirely ercome, and the sea forces its way due north across the present trance of Torbay to Hope's Nose and beyond, where, however, we ed not follow its victorious career. The south-westerly gales ving failed to overcome the massive Berry Head limestones, wn Channel easterly gales attacked the new line of coast, at right gles to the original course of marine erosion, and cut out Torbay. w it is clear that the northern Torbay raised beaches could not ist till the coastline had reached their positions, nor could the uthern Torbay raised beaches exist till after the east and west osion of Torbay had made much progress. Thus the erosion that ok place between the first attacks on the Prawle coast and the rmation of the Torbay beaches is a measure of the time that apsed between those two events; and the subsequent erosion of rbay westward and of the great west bay northward is measure of the time that has elapsed since the formation of the rbay raised beach platforms or 'shore ledges.' The latter ount of time elapsed carries us back to a period when *Trophon ncatus* was abundant in the English Channel, whereas now it is sent therefrom. But how much further back does the earlier riod of erosion take us? That is the question. But that remote riod witnessed the commencement of marine erosion on the rawle coastline.

Geologists make free with local elevations and subsidences, but e fact seems clear that at Bridlington, in the Prawle district, and the south-east coast of Ireland, sea and land at these distant calities are now within a few feet of the levels they occupied in e remote Pleistocene past.

I sometimes wonder whether the time is irrevocably passed, and the opportunity irretrievably lost, for these problems to be solved. Not only has the resistance to these problems on the part of scientific authorities been most marked in my own case, but the whole aims and objects of the British Association for the Advancement of Science by Research have been altered. The Association is now openly advocating the principle of teaching by professional men. A leading scientific weekly rejoiced that the Association was so much more in the hands of professionals at Cambridge in 1904 than it was at Cambridge in 1862; and I cannot but acknowledge that subjects which won for me the General Committee in 1879 would not now find me a place on a Sectional Committee. I cannot pretend to say that I do not regret it. I regret it very much, not for my own sake, but for the sake of what seems to me a most profitable object of research, a subject which in the hands of such men as Lyell, De la Beche, Godwin-Austen, and Daniel Pidgeon would have borne much fruit: for in science, as in agriculture, the harvest must be gathered when the crops are ripe; missed opportunities often, nay generally, do not recur.

VIII.—ON THE RELATION OF THE SANDS AND CLAYS OF DORSET AND HANTS TO THOSE OF BOVEY TRACEY.

By the Rev. O. FISHER, M.A., F.G.S.

I HAVE read with interest Mr. Lowe's article[1] on Devonshire geology, in which he discusses the question whether the Bovey beds are Miocene or Eocene, and what may be their relation to the Hampshire and Dorsetshire Lower Bagshots.

In former years I have had some acquaintance with the Hants and Dorset beds, and I have seen the Bovey deposit and was struck with their similarity. I am much impressed with the weight of Mr. Lowe's objection that the enormous amount of detritus represented by the sands and clays extending from Bournemouth—or we may even say from Whitecliff Bay, I.W.—to Bovey can hardly have been derived from so small an area as Dartmoor.

My own impression is that there once existed an area of plutonic rocks in the Channel which supplied the clays and sands of the Hants and Dorset Bagshots. We know not to how great a distance the southern edge of those beds may have originally extended. As far as they are exposed, from Blackdown west of Dorchester to Whitecliff Bay, they are truncated by a great upcast fault. They may, for aught we know, have once extended to the foot of a granitic range now no more. The surface contour of the area south of their basset edge must have been profoundly altered by that great disturbance, and there is no impossibility in there having been a lake or lagoon in which Bagshots were deposited where now Cretaceous and Jurassic strata have been protruded. Such an explanation of the phenomena would bring the Hants and Dorset Bagshots into the same category with the Bovey deposit, both being he washings of granite uplands, standing respectively in near roximity to the areas of deposition.

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[1] See GEOL. MAG., June, 1905, p. 269.

I believe the idea of a granitic source in what is now the Channel irst occurred to me from observing many crystals of pink felspar, ery little rolled or broken, lying on the surface of the heath a few niles east of Dorchester. This was more than fifty years ago; but think the locality will be found near the spot marked "Dick of he Banks" on the ordnance map. Unless I am mistaken the felspar f Dartmoor is white or grey, so that these crystals being pink oints to a different source of origin. Boulders of plutonic rocks ocur on the shore at Selsea, showing that such rocks must have xisted in the Channel area.

As to the question whether such a subaerial source of granitic letritus as I have suggested can have existed in the Channel area luring Eocene times, we find that Godwin-Austen considered the hannel to be a valley of depression, and thought that it might have een dry land until Pleistocene times; while his contour chart of he sea bottom shows a remarkable shoal, rising within seven athoms of the surface, nearly opposite the eastern end of the Isle f Wight.[1] May not this indicate the position of the remnant of former boss of granite?

REVIEWS.

.—RECHERCHES GÉOLOGIQUES ET PÉTROGRAPHIQUES SUR L'OURAL DU NORD. 2nd memoir. By Professor L. DUPARC and Dr. F. PEARCE. Mem. Soc. de Phys. et d'Hist. Nat. de Genève, vol. xxxiv, p. 383 (1905). pp. 219, 1 map, 5 plates, 30 figures, and 29 cuts in text.

THE first part of this memoir, dealing with the physiography of the Northern Urals and the petrography of Mount Koswinsky, ppeared in 1902, in an earlier fascicule. Like it, that before us xhibits the most conscientious elaboration of every detail, especially etrographic—possibly sometimes carrying this almost to an excess —and describes the Tilaï-Kanjakowsky-Cérébriansy chain, with the etrography of its rocks and their modes of occurrence from west to ast, from the watershed between the two continents up to the Devonian f Koswa. It contains illustrations of scenery which confirm the mpression, produced by the former part, that for a comparatively nountainous region it is bare and rather monotonous. Its rocks f deep-seated origin are: (*a*) pyroxenites with olivine and nagnetite; (*b*) gabbros of various types and structures, often conaining olivine; (*c*) gabbros with uralite and diorites: the hornblende bundant, the olivine rare; (*d*) norites with hypersthene and liallagic diopside; (*e*) dunites with partially serpentinized olivine nd chromic iron. The dyke or vein rocks are: (*a*) dunites, often nore completely serpentinized; (*b*) berbachites (granular aggregates f diallage, magnetite and Labrador felspar); (*c*) hornblendic pegmatites; (*d*) garewaïtes (granular aggregates of olivine, basic plagioclase, and chrome-iron, with porphyritic crystals of pyroxene). Rocks composed largely of the last mineral, which frequently belongs to the diopside division (or occasionally hornblende), seem to be very characteristic of the northern part of the Ural chain. The former memoir distinguished one of these, composed of lamellar pyroxene, with olivine, magnetite, and some hornblende, by the name koswite, and the present one describes and figures other examples, together with tilaïte, a granular rock, consisting of pyroxene (chiefly), with magnetite or spinel, a little plagioclase felspar, and occasional representatives of the following: olivine, hypersthene, hornblende, and biotite. The rock evidently is intermediate between the true pyroxenites and the gabbros, to one or other of which it may incline. Chemical analysis shows it to be richer in alumina, lime, and silica, but poorer in magnesia than the picrites, while it is richer in lime and silica, and poorer in alumina, lime, and magnesia than the troktolites. Thus the coinage of a new name is justifiable. The rocks of the Northern Urals evidently contain some very interesting types, and Professors Duparc and Pearce deserve the gratitude of students for their exhaustive memoirs. T. G. B.

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[1] "On the Valley of the English Channel": Q.J.G.S., vol. vi.

II.—Le Minerai de Fer de Troïtsk. By Professor L. Duparc and Professor L. Mrazec. pp. 115, 6 plates, 2 geological maps, and 13 figures in text. (St. Petersburg, 1904.)

RATHER thick banks of magnetite are worked, at more than one place, near the village of Troïtsk, in the Urals, at the junction of a granite-porphyry and a black schistose rock, referred to the Lower Devonian. M. Krasnopolsky gave a short description of the district in 1889. He and Professor Mrazec now publish a more minute account, accompanied by full petrographical and mineral details, proposing an hypothesis to explain the presence of the ore that is found to occur as enclosures in the granite-porphyry as well as in layers which are separated by bands of 'cornéenne' variable in thickness. Of the latter there is more than one type, of which they give petrographical studies, assigning its metamorphism to the granitic rock, which also is fully noticed. The Devonian strata are shown to be considerably more recent than the 'cornéenne.' As the authors agree with Professors Michel-Levy, Barrois, and La Croix in attributing important chemical changes to the action of intrusive rocks like granites (admitting, however, that there are two sides to the shield), they offer the following explanation of the presence of the magnetite. This was introduced into the 'cornéennes' by the magma which furnished the granite-porphyry, but its position is due to the action on the sedimentaries, and comes from a fixation in them of the iron, derived from that magma. They believe the latter to have mounted slowly, and to have formed, under orogenetic pressures, a kind of laccolite which absorbed some of the covering rocks and developed the magnetite in adjacent masses, thus forming the zones of ore near the contact. Then increased pressure ruptured the covering rocks, ejecting a quantity of magma, and enveloping fragments of them already mineralized, thus forming the ore deposits surrounded by the granite-porphyry. The crystallization of that rock then became complete, after which the mass was elevated and exposed to denudation during the formation of the Devonian rocks, and at later periods was affected, as described, by other earth movements. The explanation is not without its difficulties, which cannot be stated in a few words, but that does not affect the value of the treatise as a conscientious piece of work, and a history of a very remarkable mineral deposit. T. G. B.

III.—Dr. O. Abel. Fossil Sirenia of Austria.

Die Sirenen der mediterranen Tertiärbildungen Österreichs. —Abhandlungen der k.k. Geologischen Reichsanstalt. Bd. xix, Heft 2, pp. 1–223, with 7 plates and 26 text-figures. (Vienna, 1904.)

THIS is perhaps the most valuable memoir on the Sirenia that has appeared for some years, for although from the title it might be supposed to deal only with the fossil Sirenia from the Austrian tertiaries, this is far from being the case. The author first discusses in considerable detail the limits of the genera *Halitherium*, *Metaxytherium*, and *Felsinotherium*, and describes the peculiarities of their skeletons and teeth. He points out that these genera are a succession of forms passing more or less one into the other. *Halitherium* ranges from Upper Eocene to Lower Miocene, *Metaxytherium* from Lower Miocene to Pliocene, while *Felsinotherium* is confined to the Pliocene. In the second part of the memoir the writer describes in detail remains of *Halitherium Christoli*, *Metaxytherium Krahuletzi*, and *M. Petersi* from the Austrian Miocene.

The third part of the memoir is perhaps the most valuable and interesting. It consists of a discussion of the modifications of the Sirenian skeleton from the earliest known forms from the Middle Eocene of Egypt to the types still existing. Each of the important parts of the skeleton is considered in turn, and it is shown that in each there has been a gradual modification in a definite direction. Thus the earliest types possess a full set of incisors and canines which disappear in the later forms, their place being taken by the horny covering of the front of the jaws, though in some cases a pair of tusks, probably equivalent to the second incisors, may persist. In the molars there is a gradual increase of complexity resulting from the addition of secondary tubercles to a primitively bilophodont tooth, each transverse crest of which consists of a pair of cusps. Still more important are the changes that are shown to take place in the pelvis. For the first time the author figures and describes a Sirenian pelvis in which all the elements are complete, the obturator foramen being entirely enclosed by the ischium and pubis as in ordinary land mammals. This primitive form of pelvis is found in *Eotherium* from the Mokattam Limestones (M. Eocene) of Cairo, a Sirenian first described by Owen from the cast of a cranial cavity, and its discovery is a great step towards bridging the gulf between the Sirenia and their terrestrial ancestors.

Eotherium clearly must have possessed a functional femur which was probably not employed exclusively in swimming, but shows that this undoubted Sirenian may have been to some extent amphibious. Moreover, this pelvis is extremely similar to that of *Mœritherium*, a nearly contemporary Proboscidean, a circumstance that constitutes another piece of evidence in favour of the view that the Sirenia and Proboscidea have a common origin.

Finally, the fourth part of the memoir is devoted to the consideration of the genus *Metaxytherium*, and the result that the author arrives at is, that, while *Manatus* is in many respects different from the other members of the group, *Eotherium*, *Eosiren*, *Halitherium*, *Metaxytherium*, *Felsinotherium*, *Halicore*, and *Rhytina* form a closely related series.

The memoir is illustrated by excellent photographic plates illustrating some of the more important series of modifications in different elements of the skeleton. C. W. A.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—May 10th, 1905.—R. S. Herries, M.A., Vice-President, in the Chair.

The Chairman announced that the Council had resolved to award the Proceeds of the Daniel Pidgeon Fund for 1905 to Thomas Vipond Barker, B.A. Oxon., who proposes to investigate the deposition of crystals of minerals and other substances in regular position on each other, with special reference to such groups as those of calcite, barytes, aragonite, etc.

The following communications were read:—

1. "The Geology of Dunedin (New Zealand)." By Patrick Marshall, M.A., D.Sc., F.G.S.

The paper opens with an account of the physiography of Otago Peninsula and the adjacent mainland, in which the origin of the land-forms is briefly discussed. The author then passes on to a detailed account of the petrography of the district. The age of the oldest rocks seen, mica-schists, is not definitely known; they have been referred to the Archæan and to the Silurian systems. They are followed by about 1,000 feet of Tertiary sandstones and limestones, which contain sufficient fossils to class them with the Oamaru system of Oligocene age (Hutton) and with the Cretaceo-Tertiary of the Geological Survey. Fine, plant-bearing shales succeed unconformably; and upon these, again, rests a pumice or light scoria bed. These rocks are in their turn covered by the igneous rocks next described.

The rocks described include an ill-exposed, gold-bearing syenite; a diorite, with an uneven and weathered surface, underneath the lavas; rhomb-porphyry containing anorthoclase, and partly intrusive, partly interbedded; tinguaite, in the form of dykes; hypabyssal trachydolerite, containing nepheline and ægirine, and sometimes sodalite and analcite; a teschenite dyke; and trachyte, notably lacking in ferromagnesian minerals, occurring in dykes and lava-flows. A large number of trachytoid phonolites occur in the form of interbedded sheets; they are divided by the author into five principal varieties, one of which bears leucite. Nephelinitoid phonolite is rare. A considerable number of rocks are classified as trachydolerites apparently occurring as lavas. The andesites are characterised by hornblende and augite, with little or no olivine; basanite is restricted in its occurrence. Dolerites of two principal types occur in dykes, one type being the commonest of all the rocks in the area. There are many lava-flows and some dykes of basalt; and one melilite basalt is found in the extreme north of the district. A note is appended on the economic application of these rocks.

A considerable series of chemical analyses follows, showing that the silica percentage varies from 66 in the Portobello trachyte to 44·84 in one of the dolerites. The petrographical differences are coincident with the chemical differences, and the rocks are generally similar to rocks of the same classes in other parts of the world, and more particularly to those of East Africa. A classification is attempted, according to the methods proposed by Pirsson, Washington, and Iddings; but the author concludes that, in his case, this classification, while grouping the rocks according to their chemical relationship, is unsatisfactory from a geological standpoint. The chemical composition of the rocks is further represented in diagrams constructed according to the method employed by Hobbs. These diagrams show clearly the chemical differences between the alkaline and the basic series, and the extent to which this hiatus is bridged over by the trachydolerite and basanite. The series, however, does not show a gradation similar to that described by Professor Brögger in the Christiania rocks.

In the concluding section of the paper the relative ages of the volcanic rocks are worked out, so far as possible. The order does not appear to be explicable on any theory of magmatic differentiation, but it is suggested that it may be due to the mixing of magmas before and during eruption.

2. "The Carboniferous Limestone of the Weston-super-Mare District." By Thomas Franklin Sibly, B.Sc. (Communicated by Dr. A. Vaughan, B.A., F.G.S.)

The Carboniferous Limestone of the Weston Worle Ridge includes the greater part of the *Syringothyris* zone (C), extending from the '*laminosa* dolomites' upwards, and a large part of the *Seminula* zone (S). While the dip of the rocks of the ridge is towards the south, a reversed fault throws the *Syringothyris* Beds on the south against the *Seminula* Beds to the north, and the latter rocks are overfolded on the north side of the fault. To the south of the fault there is a sequence from C_1 to S_2; to the north, S only is represented. The lower part of C_1, consisting of the '*laminosa* dolomites' and the '*Caninia* Oolite,' resembles the equivalent part of the Clevedon sequence, and indicates shallow-water conditions; the upper part of C, consisting of a thick mass of fossiliferous limestone, closely resembles the corresponding part of the Burrington section, and indicates the predominance of a Mendip facies. Much dolomite occurs in the lower part of S, indicating shallow-water conditions during part of *Seminula* time. There is a distinct development of the *semireticulatus* subzone (S_1), which exhibits a faunal overlap between C and S; and the base of S_2 is remarkable for its rich and varied fauna.

The Woodspring Ridge shows a sequence from the Upper *Zaphrentis* zone (Z_2) to the top of C_1, the whole sequence being exactly similar to that of Clevedon. In this ridge the contemporaneous igneous rocks occur in horizon γ. In the Weston Worle Ridge they are put above the '*Caninia* Oolite,' that is, about 450 feet below the top of C. It is, therefore, evident that there were two periods of volcanic activity, one of which occurred at the close of *Zaphrentis* time and the other early in *Syringothyris* time. Notes are given on the faunal sequence.

II.—May 24th, 1905.—J. E. Marr, Sc.D., F.R.S., President, in the Chair. The following communications were read:—

1. "On the Igneous Rocks occurring between St. David's Head and Strumble Head (Pembrokeshire)." By James Vincent Elsden, B.Sc., F.G.S.

The author finds that the contemporaneous lavas of the Llanrian area agree generally in character with the eruptive rocks of apparently Ordovician age in the Strumble Head and Prescelly districts. These are all of an essentially acid type. The intrusive rocks of the area are of later date, and belong to three distinct types:—(1) The gabbros and diabases of the Strumble Head area; (2) the norites and associated rocks of St. David's Head and the surrounding district; and (3) the lime-bostonites and porphyrites of the Abercastle Mathry district. Detailed petrographical descriptions of the different types are given, accompanied in many cases by analyses and comparisons with corresponding or related rocks of other areas. The lime-bostonites, which have affinities with those of Mæna described by Brögger, but are much more basic than the Wicklow keratophyres, are apparently the oldest of the intrusive rocks, and seem to belong to the petrographical province of South-Eastern Ireland. The gabbros and norites were intruded approximately during the same interval; at a later period the norites, enstatite-diorites, and the rest of the rocks associated with them spread north-eastward from St. David's Head, and penetrated the area of the Strumble Head intrusions. Similarly, the gabbros and diabases spread to a more limited extent south-westward into the norite area. In the overlapping area the gabbro and norite provinces are separated by an ill-defined zone, in which some mixture of the two magmas took place. The latest phase of igneous activity was the formation of the Pen-Caer basalt-laccolite, with apophyses penetrating the Garn-Fawr to Y-Garn intrusions. It is not necessary to assume that each of the several intrusions was confined to any single stage of vulcanicity. The laccolites and bosses were probably the result of injections extending over a prolonged interval from co-existing magma basins, or from a single differentiated magma. There are clear evidences of some further differentiation *in situ*, but the full extent to which this took place offers a large field for future investigation.

2. "The Rhætic and Contiguous Deposits of Glamorganshire." By Linsdall Richardson, F.G.S.

The principal sections in the county are described in detail, the chief being those at Lavernock (near Cardiff), Barry, Tregyff (near Cowbridge), Quarella (Bridgend), and Stormy Down. The Sully Beds, a name given to the fossiliferous portion of the 'Grey Marls' of Etheridge, are determined to belong to the Rhætic Series, on account of the fossils that they contain. They are quite distinct from the 'Tea-Green Marls,' in which fossils have not been observed. Earth-pressures affected the rocks during the formation of the Sully Beds; the *Avicula contorta* black shales rest upon them with perfect parallelism, but even then non-sequentially. Owing to an upheaval of the Lavernock district early in the age in which the Upper Rhætic Stage was deposited, only a portion of the lowest bed of that stage is found, and this deposit was subjected to subaërial denudation during the accumulation of the remaining Upper Rhætic beds elsewhere. But subsidence again in the same district allowed of the deposition of the White Lias, and as a result this latter rests non-sequentially upon a portion of the lowest part of the Upper Rhætic deposit. The White Lias, at certain localities in Glamorganshire, contains in abundance *Plicatula intusstriata*, *Pl. hettangiensis*, and *Lima valoniensis*. The deposit intervening between the Sun Bed and the Upper Rhætic near Bath (Newbridge Hill) is over 11 feet thick; at Lavernock the equivalent deposit measures but 2 feet 2¼ inches. At Lavernock, however, above the probable equivalent of the Sun Bed, are marls 6 feet 4 inches thick, which are provisionally grouped with the White Lias. Above come the Paper Shales, succeeded by the *Ostrea* Beds. The Upper Rhætic of North-West Gloucestershire and Worcestershire is not the equivalent of the White Lias of this or of the Bath district. The White Lias occurs above the Cotham Marble (the topmost bed of the Upper Rhætic) and below the Paper Shales (which occur immediately below the *Ostrea* Beds). Palæontological notes on certain of the fossils are appended, including *Ostrea Bristovi*, Etheridge MS., which is very abundant in the Sully Beds.

3. "On the Occurrence of Rhætic Rocks at Berrow Hill, near Tewkesbury (Gloucestershire)." By Linsdall Richardson, F.G.S.

About 2 miles south-east from Chase End Hill (Malvern Hills) there is a small outlier of Lower Liassic and Rhætic beds, in a basin-shaped area, supported and surrounded by Keuper Sandstone. A detailed section is given, mainly obtained by excavation, and this is compared with the nearest locality where the whole of the Rhætic may be studied, namely, at Wainlode Cliff. At Berrow Hill rock at the base of the Lower Rhætic, at least 3¼ feet thick, is missing; consequently Bed 13 rests directly, and with perfect parallelism (so far as can be seen), but non-sequentially, upon the 'Tea-*Green Marls.*'

III.—June 7th, 1905.—J. E. Marr, Sc.D., F.R.S., President, in the Chair. The following communications were read:—

1. "The Microscopic Structure of Minerals forming Serpentine, and their Relation to its History." By Professor T. G. Bonney, Sc.D., LL.D., F.R.S., V.P.G.S., and Miss C. A. Raisin, D.Sc.

The authors, after a brief reference to investigations of serpentine during the last thirty years, which still leaves some points unsettled, describe the formation of that mineral from sundry ferromagnesian silicates. Having given a summary of the changes in olivine, they describe more fully the alteration of separate grains in the so-called 'kimberlite' of South Africa. Then, after referring to the serpentinization of amphibole, as illustrated in the well-known Rauenthal rock, they enter more fully into the changes, first, of the orthorhombic pyroxenes; then of the monoclinic. To illustrate the latter, they describe the conversion of malacolite into serpentine in the well-known '*Eozoon*' rock of Côte St. Pierre, and of some augite-bearing serpentines in the Vosges. An investigation follows of the form of serpentine called 'antigorite,' described by Dr. Hussak (in 1883) from Sprechenstein on the Brenner Pass, and asserted to exhibit a 'netting-like' (*gestrickte*) structure, which is a record of the nearly rectangular cleavage of the original augite. They show, by study of specimens collected in the Sprechenstein district by Miss Raisin, that no such connection exists, and that the netting-like structure has often only a subjective existence.

The mica-like mineral called antigorite is shown to be abundant in the Pennine Alps about the head of the Viepthal, and to lead to the same conclusion, suggesting, no less than the Sprechenstein specimens, a relation between that mineral and pressure. After a brief notice of the chemical changes in the conversion of the various anhydrous silicates into serpentine, the authors embody their investigations in the following conclusions:—

(1) That both a tint and pleochroism are accidental rather than essential characteristics of antigorite.

(2) Neither are low polarization-tints characteristic, unless two mica-like minerals exist, otherwise indistinguishable.

(3) That it is doubtful whether any hard-and-fast line can be drawn between antigorite and the more fibrous forms in ordinary serpentine rocks.

(4) That the most typical antigorite appears when the rock has been considerably affected by pressure, but it becomes less so when the latter has been very great.

(5) That so far from the nearly rectangular cleavage of augite originating the 'gestrickte struktur,' it is worse preserved than any other original one in the process of serpentinization. Typical antigorite, however, apparently is rather more readily produced from augite than from the other ferromagnesian silicates, but is more directly a consequence of pressure than of chemical composition.

2. "The Tarns of the Canton Ticino." By Prof. E. J. Garwood, M.A., Sec. G.S.

The lakes dealt with comprise the larger Alpine tarns which occur in the Canton Ticino. Most of these drain into the Ticino basin; one or two, however, flow into the Reuss or the Rhine.

Val Piora Lakes.—These are chiefly rock-basins which lie in all cases along the junction of two dissimilar rock-masses. Detailed soundings prove that the axes of greatest depth of the lakes coincide with these lines of junction: one side being a dip-slope, the other an escarpment. It is shown that in the case of three of the larger lakes soluble calcareous beds have been brought by thrusts against crystalline rocks.

The origin of the lakes cannot be attributed to ice-excavation, as the ice must not only have invaded the district from outside, but must also have come from several different directions at once. Other difficulties in the way of accepting this mode of origin are also pointed out.

They appear to be due to structural peculiarities of the district, aided by solution. Analyses of the rauchwacké are given, and its characters are described.

The lakes appear to be connected with a reversal of the drainage of the Piora Valley, consequent on the over-deepening of the Val Levantina in Interglacial times and the elevation of the upper end of the district as the ice-cap melted away.

Two of the other lakes of this group lie on or near the watershed: their origin is difficult to account for, except by differential weathering along the lines of junction.

Lago Tremorgio Group.—These tarns are all situated either on the calc-mica-schists or on outcrops of crystalline limestone and dolomite. Lago Tremorgio itself is almost certainly due to solution. A typical analysis of the schists gives 75 per cent. of calcium-carbonate. This occurs chiefly in the form of eyes of granular calcite which crumble between the fingers, and is found to be dissolved out in the submerged rock, while sharp reefs run out under water.

Soundings show a depth of 150 feet near the exit, which is a narrow water-cut gorge. The lake is otherwise entirely surrounded by a steep wall of rock, the lowest point in which is 718 feet above the lake. It is impossible to suppose that ice has scooped out this basin. The fact that springs issue from the side of the valley below the lake all the year round, and that the level of the lake falls 20 feet below its exit in Winter, points strongly to solvent action.

Of the remaining lakes scattered along the southern side of the Ticino watershed, the Lago di Naret has a wedge of crystalline limestone running through the centre, while the Lago Sciundrau is situated on the junction of dolomite and gneiss, and the Laghetti to the east of Lago di Naret lie along the junction of the calc-schist and the gneiss.

The St. Gothard Lakes.—The rock-basins here also occur along the line of junction of schists and gneiss. The Lago Lucendro is the most important, and soundings show an axis of greatest depth running along this junction. Solution does not appear to have played much part in its formation. Possibly the glacier which descended from *Piz Lucendro* has removed fragments along the junction, as a transporting, not an excavating agent, as proved by the soundings at the lower end of the lake.

Lago Sella and Lago Orsino are shallow tarns which come under the same category as Lago Lucendro.

Lago d'Elio, draining into the Lago Maggiore, is due to reversal of drainage by a landslip.

These lakes, then, owe their origin, when they are rock-basins, to the presence of lines of weakness, along which in many cases solution has taken place, while in some shallow tarns ice may have removed detached fragments; but in no case has a lake been found which can reasonably be assigned to ice-excavation independent of rock-structure.

CORRESPONDENCE.

ICE OR WATER.

Sir,—Professor Bonney's review of Sir Henry Howorth's new book in your June number just received leaves some of us in a fog. We gather that he thinks the author has seriously damaged some of the positions taken up by the extreme Glacialists, by whom we presume he means Mr. James Geikie and his followers. We gather, on the other hand, that he thinks Sir Henry Howorth's book an extravagant presentation of the other side, and contrasts Scylla with Charybdis. He apparently feels himself to be in a safe harbour, free from the perils on either side. This does not help us, however, very much. What is now felt to be the important matter, especially by the younger men, is to know where the moderate Glacialist can stand, and as Professor Bonney has himself written a book on the Ice Age, we turned expectantly to his review for some help in this matter, instead of which we get some jokes and some generalities, among which we find it difficult to quite understand how the problem now stands, and how far it has been solved or otherwise by the author. I know nothing that would be more welcome to a large number of puzzled young geologists than a frank statement of his own views in your pages by one who has taught them so much as Professor Bonney. Will he tell us where he thinks they may safely stand, and what limitations he would put on the glacial theory as generally taught by its advocates? A PERPLEXED F.G.S.

Letton, Herefordshire,
June 19th, 1905.

OBITUARY.

W. T. BLANFORD, C.I.E., LL.D., F.R.S.

Born October 7, 1832. Died June 23, 1905.

As this number is passing for press, we have, with deep regret, to record the sad news of the death of another distinguished geologist and contemporary, Dr. W. T. Blanford, Treasurer, since 1895, of the Geological Society, and a past President (1888–90). He died, after a very brief illness, at his residence, 72, Bedford Gardens, Campden Hill, W., 23rd June, 1905, in his 73rd year.[1]

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[1] See Life and Portrait, Geol. Mag., January, 1905, pp. 1–15.

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE V. VOL. II.

No. VIII.—AUGUST, 1905.

ORIGINAL ARTICLES.

I.—The Recent Geological History of the Baltic.
Part II: The Ancylus Sea and the Baltic Breach.

By Sir H. H. Howorth, F.R.S., F.G.S.

(PLATE XIX.)

IN the previous paper I ventured to trace the history of the Baltic back to the time when the latest of its raised beaches were laid down, and to show that it was then considerably larger in size, and that its waters were more salt than they are now, although they were even then brackish (see Map I, Pl. XIX).

This conclusion was derived mainly from an examination of the molluscan remains in the more recent shell-beds. It is confirmed by other evidence; thus, Munthe mentions the occurrence in the so-called *Litorina* beds of three species of Rhizopods, whose present and former distribution in the Baltic is shown in the following table:—

	Present Distribution.	In Litorina Strata.
Nonionina depressula	Warnemünde	N.W. of Neder Kalix.
Polystomella striatopunctura	Warnemünde	Hernön and Gånsvik.
Rotalina Beccarii...	Great Belt and the Sound S. of Hven ...	Åland, Knutsboda, Obbnäs, 35 km. S.W. of Helsingfors.

The specimens of these three species from the *Litorina* deposits seem, says Munthe, to be dwarf forms, and their distribution, like that of the before-mentioned marine organisms, point to different hydrographic conditions from the present (Geol. Inst. Upsala, vol. ii, p. 36).

Our present ignorance of the distribution of the Ostracoda in the Eastern Baltic prevents our making the same minute induction in regard to them, but Munthe says that in general the fossil Ostracodan fauna also points to different hydrographical conditions from the present (id., p. 38).

In regard to the marine diatoms and their distribution there is more than one ambiguity. Munthe has, however, concluded from a minute examination of the problem that they point to a greater saltness in the *Litorina* sea than in the Baltic nowadays, and he adds that an investigation of certain recent samples taken from the South Baltic and adjacent regions proves that the diatomaceous flora of the *Litorina* sea has roughly its closest parallel nowadays in about the same region as its molluscan fauna (id., p. 32).

Having defined the extent and condition of the Eastern Baltic in the so-called *Litorina* time, we will now try and carry the story a little further. The older inquirers, and notably Lovén and Erdmann, argued that the *Litorina* sea was the direct continuation *in situ* of an older so-called ice sea, which was marked by the presence of *Yoldias* and other northern shells.

This was a mere speculation, however, since nowhere had a deposit been found showing a graduation or change from one set of conditions to the other, nor had any traces of the so-called *Yoldia* beds been found over a very large part of the area where the former presence of the *Litorina* sea was well established.

In 1887 Munthe published a very important paper condensing the results of his inquiries in the island of Gotland. In this paper he first definitely showed that the views of Lovén and the older investigators of the history of the Baltic could no longer be maintained. He proved, in fact, that instead of the *Litorina* sea being a direct successor of the so-called *Yoldia* or ice sea it was preceded over a large part, if not all the Baltic area, by a condition of things in which the Baltic formed a large fresh-water lake. To use his own words, "it became evident that the *Litorina* fauna was a completely distinct fauna and immigrated to the Baltic comparatively late, and could scarcely be supposed to have entered by any other route than that of the Sound and the Belts." The importance of this conclusion justifies me in giving its history in some detail.

The first step in defining the problem was taken by Schmidt in an addition to G. von Helmersen's memoir on the diluvial beds of Russia, published in the Memoirs of the St. Petersburg Academy in 1869. Schmidt pointed out that in Esthland, in the lower parts of the country, and in the former inlets of the Wick, there is a stratified dark clay, sometimes occurring alone, and sometimes covered with fine or coarse sands containing shell fragments, like that now being deposited in some places by the sea, and which has its equivalent in Sweden in the old inlets of the Mälar Sea. Schmidt declared this deposit as it occurs in Esthland to be of fresh-water origin, and he said it there everywhere covers the widely spread angular gravel known to the natives as Richk or Plink. He goes on to say that while in the raised beaches and terraces and deposits on the coast of Esthland remains of marine shells occur, these are not found in the interior of the country. They overspread the lowlands of the islands of Dago, Worms, Nuckö, and the neighbourhood of Hapsal. In Dago they occur at a height of 30 or 40 feet above the sea-level, and, at Pönal and Pallifer, at a distance of 20 versts from the water. Further inland, he adds, no such marine shells occur, but only fresh-water shells such as *Ancylus fluviatilis* and pieces of *Unios*.

On the mainland he found the same deposit with *Ancylus fluviatilis* at Mannalas at a considerable elevation, at Padis in gravel, and mixed with *Paludina baltica* near the church of Karusen. In some places the latter shell occurs alone. He remarks that hitherto *Ancylus fluviatilis* had not been found in the sea and only in running streams. Its near relative *Ancylus Baicalensis* is found in Lake Baikal with certain marine Crustaceans, pointing to the former union of that great lake with the Polar sea. The two shells above named also occur in the gravel mounds on the top of the island of Mohn (op. cit., pp. 55, 56).

In 1881 Geikie published his work "Prehistoric Europe," in which he has a paragraph about these fresh-water beds which is interesting as showing that the problem had then been considerably illustrated by Krapotkin and Schmidt, although he unfortunately (as Munthe also complains) does not give a reference to the memoir where their researches were published, and which I cannot trace. They argued, according to Geikie, that in Finland the fresh-water beds were older than the marine ones, and that the Gulfs of Bothnia and Finland existed at the end of the Glacial period as great fresh-water lakes, and they quote the terraces which mark their ancient margins as being found there, as they are on certain islands of the Baltic, such as Mohn and Dago. Similar terraces at higher levels have been traced in the interior of Finland up to 150 feet. "The whole region . . . . seems to have been covered, over wide regions, with extensive sheets of fresh water. In many cases the natural dams which held in their waters consisted of *åsar* or great gravel ridges that were rendered watertight by the mantle of loam and silty clay which often cloaks their slopes. The different levels of the ancient lakes as their confining barriers gave way are marked by terraces eroded in the sides of the *åsar*. It is remarkable that . . . . not a single sea-shell has yet been detected in the interior of Finland" (Geikie, op. cit., p. 470).

In 1884 Schmidt published a memoir in the Zeitsch. der Geol. Gesellsch. on the Glacial and post-Glacial deposits of Esthland, Oesel, and Ingermanland, in which he added some further facts to those here stated. He there tells us that the fresh-water shells occurring in the beaches consist in the main of *Ancylus fluviatilis* and *Limnæa ovata*, but there are also found *Unio*, *Cyclas*, *Paludina impura*, and *Neritina fluviatilis* var. In Oesel these beaches occur near Arensburg from a height of 20 feet up to 100 feet in the higher parts of the island. In Mohn they occur in the highest part of the island, near the church; while on the mainland our author reports them from Karusen, St. Michaelis, Fickel (Awaste), Piersal, Mannalas, Kegel, Hirro near Reval, and further east below the Jaggowalschen waterfall. Still further east the same beds, but without shells, occur at Kuckers, Sackhof, etc.

Schmidt in describing these deposits confesses himself unable to say whether the fresh-water beds are older than the marine (now called *Litorina* beds) or not. He adds, however, "Vielfach sieht man aber marine Sande auf Bänderthon aufliegen, der, wie gesagt stellenweise Becken bildet, die von Ancylusschichten umsäumt sind"; and says further, what I cannot quite understand, "Die hohe lage dieser Schichten auf Mohn sprecht dafür, dass bei ihres Bildung die Insel noch nicht von Festlande getrennt war. Vielleicht war den ganze Riga'sche Meerbusen ein Süsswasser becken" (op. cit., p. 266).

In 1884 Munthe recognized similar fresh-water beds at the height of 130 feet south-west of Wisby in the island of Gotland, in which he observed *Limnæa ovata* and *Pisidium ovatum*.

In the same year Holm, in a letter to Holst, implied the occurrence of these fresh-water beds in Gotland, and also foretold their occurrence in Öland (see Holst, Sver. Geol. Unters., No. 180, p. 96, note), which he definitely proved two years later in a paper published in the Geol. Fören. Stock. Förh., 1888, vol. x, p. 365.

In a visit to Gotland made in 1886 and 1887 Munthe found similar deposits at a height of 100 to 150 feet marked by the presence of *Ancylus fluviatilis*. These beds consisted of typical open beaches with pebbles and sand. Munthe tells us that in 24 sites where they occurred in Gotland *Limnæa ovata* was represented in 23, *Ancylus* in 19, and *Pisidium* in 10. In addition there were found in them *Limnæa palustris*, *Planorbis contortus* and *marginatus*, *Valvata cristata*, *Bythinia tentaculata*, several other species of *Pisidium*, including *amnicum*, *pallidum*, *fossarium*, *pusillum*, var. *major*, and three species of Ostracoda, *Cypris reptans*, *Candona compressa* and *candida*.

Munthe gives a map of the localities in the south-east of Gotland, such as När, Lau, and Burs, as well as the limestone ridges called Burgen where these deposits have been found.

In Öland Holst says that the *Ancylus* and *Litorina* beds are found well developed in the villages of Mörbylånga, Resmo, and Vickleby, on the western side of the island, although they are not so abundant there as they are on its eastern side (Sver. Geol. Und., No. 180, p. 95, note).

The occurrence of these fresh-water deposits in so many localities upon open beaches facing the sea, on the mainland as well as on the islands in the Baltic, enabled Munthe to make the very important generalization embodied in his paper already cited, and published in 1887, namely, that the Baltic was once a fresh-water sea or inland lake, and that this stage immediately preceded the *Litorina* stage in its history, since the *Litorina* beds are found overlying the fresh-water ones. From these beds being especially characterized by the shell *Ancylus* he gave them the name of *Ancylus* beds, and the sea in which they were found the name of the *Ancylus* sea.

The *Ancylus* has an outward resemblance to the limpet, and has sometimes been called the fresh-water limpet. It was, in fact, called a *Patella* by Linnæus. The northern geologists give the *Ancylus* we are discussing the specific name of *fluviatilis*, but this involves a difficulty. The shell so called is apparently limited in its habitat to shallow rivers and streams, where it occurs on stones and rocks. Jeffreys says he once found it (apparently meaning only once) of a dwarf size in a stagnant pool near Swansea, into which no stream had flowed within the memory of man, in company with *A. lacustris.* The latter shell is described by him as found on the leaves of water-lilies and other aquatic plants, as well as on fallen leaves of trees, in slow rivers, lakes, canals, marshes, and ponds, from Finland to Algeria. He identifies it with the *Patella lacustris* of Linnæus. Munthe says his *A. fluviatilis* is not only a fresh-water but a marine shell, and that he has taken it alive adhering to marine species of algæ in the Baltic (G. Jeffreys, op. cit., i, 122, 123). This latter statement makes it somewhat inconsequent to name the fresh-water sea of the pre-*Litorina* time from this shell instead of from one of the purely fresh-water forms with which it is associated.

Munthe points out the remarkable fact that the *Ancylus fluviatilis* which, he says, characterizes the fresh-water beds we are describing is not found living in the streams of Gotland. It occurs, however, in the brooks of Esthland. The fossil specimens are small and dwarfed, being 3 mm. long and 2 high, compared with the living forms. The largest specimens from the fossil beds elsewhere are 5 mm. long, 4 broad, and 3 in height, while the largest living ones from Ruysjon in Skäne are 4 mm. long and 2 high (see Overs. K. V. Ak. F., 1887 and 1888, p. 724).

These proportions seem to point to the fossil shells in question belonging to *Ancylus lacustris* rather than *fluviatilis*, for, as my friend Mr. Sherborn has pointed out to me, the chief distinction between the two shells is that one is much rounder than the other, which is more oval. As they occur in places together it may be that the forms grade into each other, at all events Forbes seems to have treated them as of one species. The matter deserves a more minute analysis at the hands of the Scandinavian geologists. Let us return, however, to the distribution of the fresh-water beds we are discussing.

The case was carried further when certain clays, not then known to be fossiliferous, which were discriminated by Von Post as far back as 1855, and were called by him 'undrediluviallera,' i.e. lower diluvial clay or lower clay, were identified with the *Ancylus* beds by Munthe. Von Post described them as found as high as 75 metres above the sea-level, and as consisting of a light grey or blue grey to dark grey bed, with little or no tendency to lamination, and when dry falling apart into fine fragments, and as containing concretions of iron oxide formed round roots from above.

Erdmann and writers in the Sveriges Geologiska Undersöknings called this clay 'undre åkerlera' (underlera), while Munthe, who identified it with the clay of his fresh-water sea, called it *Ancylus* clay. It has been recognized as existing in Upland, Vestmannland, and Nerike, and probably in various parts of Eastern Sweden (op. cit., p. 263). At Skattmansö, in Western Upland, these *Ancylus* beds are found of a thickness of 3·55 metres and at a height of 36 metres above the sea, and containing a large number of fresh-water diatomaceæ, including the now probably extinct *Eunotia Clevei*, which has appeared in other Ancylus beds (Nathorst, Sveriges Geologi, pp. [illegible]).

De Geer has estimated that the Ancylus sea extended over [illegible] square kilometres ([illegible] miles) and included the whole Baltic area with Finland and Lake Ladoga (see Nathorst, op. cit., pp. [illegible] and [illegible], where a map of the Ancylus sea is given).

The facts here mentioned and others similar to them have satisfied the Northern geologists that the recent history of the Baltic involves its having been first a widely spread fresh-water sea and then a brackish-water one more salt than the present Baltic, which has gradually become less salt until it acquired its present condition.

The change here mentioned from a fresh-water sea to a brackish one involves one inevitable corollary, namely, that at a not remote time in its history the Baltic must have been entirely shut off from the North Sea and been a completely enclosed lake. This conclusion again has been found to exactly harmonise with other evidence forthcoming from other sources and which I will shortly produce.

Anyone who looks at the broken and irregularly outlined Danish islands separated by their narrow sounds and belts and partially closing up the space between Zealand and Skåne in Sweden, will be impressed by their resemblance to a ruinous remnant of a formerly continuous land surface. This appearance is fully borne out by the actual evidence, which proves that the whole area has sunk considerably in comparatively recent times. A movement of elevation subsequently intervened and affected a portion of the sunken surface. This is very plainly shown by the fact that all along the coast of Skåne and elsewhere in this area the marine beds of recent origin, which are found at a small elevation above the sea and whose shells show they belong to the *Littorina* period, frequently lie upon turf or upon beds containing land shells and land plants, as has been pointed out by many observers. This proves that the district in question, which was once dry land, has at one time been sunk below the water sufficiently deeply and long to get a covering of marine deposit upon it, and has been then raised again to its present level. The first person who argued that the land off the coast of Skåne had sunk was J. C. Wilcke, who, writing in 1770 in regard to the harbour of Landskrona, notices how in the banks bounding its entrance and which are covered by five or six feet of water there are found trunks of rotten and upright trees, showing that the submerged ground was once a wood, and tells us how he had been told in 1767 that a large oak with its trunk and branches intact had been found under six feet of water.

On the oyster ground Wilcke found decayed trunks in a layer of submerged mould, in which they had probably grown, and he considered the layer of soil marked the former level of the land, which had therefore been about five feet below the main level of the water. These facts led him to the conclusion that there had been a considerable subsidence along the coast.

In 1847 Nilsson published his well-known work on the

Scandinavian fauna. In this he enlarged, *inter alia*, on the evidences of a general sinking of the land in very recent geological times along the coast of Skäne. He mentions the discovery of submarine turf in many places along the coast from Dybeck as far as the district between Trelleborg and Falsterbo. Over 200 feet from the shore is a bed of turf about two feet deep under the sea and six feet thick. A similar bed of peat lies near the fishing village of Skäre. Again, three-quarters of a mile from the land and on the ground known as Falsterbo there lies a great mass of peat of several acres in extent and 10 to 12 feet in thickness. It is 24 to 26 feet below sea-level, and contains various kinds of land and fresh-water products; *inter alia*, it contains a number of large and small trees, such as oak, birch, alder, aspen, and fir, mixed with leaves in all its various layers, of hazel, willow, sallow, together with hazel-nuts, pine cones, Equisetæ, etc., etc. (Geol. Fören. Stockholm Förhandlingar, i, 101).

Nilsson by careful measurements at Falsterbo has shown that the sea has gained considerably on the land. A small island called Kläppen has almost disappeared, while extensive beds of submarine turf formed in fresh water are now found at a depth of from 10 to 14 feet below the surface of the sea. These submarine turbaries, he says, occur in many places, some near the present coast and some at a great distance away and at great depths. In enlarging the port of Malmö in 1874 a submarine turbary was found containing flint flakes.

During the years 1874–5 some excavations were made in the port of Ystad, which were closely watched and reported upon by M. Bruzelins, then living there. The space reported upon by him consisted of three Swedish acres or six French hectares. The surface layer of the deposit was sand, below which, and at a depth of three metres below the mean level of the water, there was a peat bog varying from 40 to 25 centimetres in depth. In this peat were a number of trees still attached by their roots. Below the peat was a layer varying in composition, sometimes sand, sometimes blue clay, and sometimes a mixture of sand and clay, and containing many striated pebbles.

In the bed of sand above the peat were shells of *Mytilus edulis*, *Mya arenaria*, *Tellina balthica*, and *Cardium edule*, mingled with the wreckage of 38 ships, one of which, loaded with tiles, dated from the middle ages, and there were found a number of objects of metal —caldrons, etc., two arquebuses, dating probably from 1450 to 1500, and six cannon-balls. There were also found a number of other domestic objects, enumerated by Bruzelins, all probably dating from two to four centuries ago, together with a large number of skulls and bones of oxen and horses, skulls of dogs, swine, sheep, goat, and roebuck, bones of the fox and cat, and one or two human jawbones. All the objects in this layer belonged to the modern world, and none reached back to pagan times or the earlier part of the middle ages.

In the peat below the sand were many roots of aquatic plants.

In the peat Professor Torell found a number of forest-living shells, such as *Helix*, *Clausilia laminata*, *Vertigo costulata*, *Zua lubrica*, *Succinea putris*, etc., besides which were a number of fresh-water shells, including three species of *Limnaea*, eight of *Planorbis*, two of *Bythinia*, *Physa fontinalis*, *Ancylus lacustris*, *Valvata cristata*, *Anodonta*, etc.; there were also elytra of aquatic insects, branches, leaves, and fruit of trees such as oaks, hazels, alders, etc., and aquatic plants such as *Calla*, *Myriophyllum*, *Ceratophyllum*, *Nuphar*, etc. Only three tree trunks occurred, one of oak and two of alder.

In the sandy clay below the peat there occurred at a depth of 30 centimetres a knife of grey flint; six inches from this was found a polished and broken axe of yellowish flint, at a depth of 15 to 20 centimetres a mace of bronze with four projecting points and twelve round studs on it, a dagger, a knife of flint 20 centimetres long and with its point broken, some bone objects which looked as if they had formed part of a sledge, two objects which gave rise to some discussion afterwards; and, lastly, two pieces of bone which had served to haft a knife, which were artistically wrought and terminated with the head of a dragon. These objects M. Bruzelius dated approximately between the eighth and eleventh centuries, and he argued that the subsidence of the peat bog had taken place some time between the eighth and eleventh centuries.

In the discussion which followed M. Bruzelius' paper at Copenhagen, C. Vogt and Bertrand urged that the subsidence of the ground as evidenced by the majority of the facts mentioned, took place some time during the Stone or Bronze age, while the presence of the solitary object, the knife handle, was accidental and explainable in another way (see Comptes Rendus Cong. Prehist. Arch. Copenhagen, 1873, pp. 15–30).

Nathorst says that round the coasts of Zealand are found similar witnesses to a post-Glacial sinking of the land as in Skäne, in the shape of peat bogs and submerged river-beds under the sea. Subsequent elevation of the ground has again raised these beds as in Skäne above the sea-level, the latter process being evidenced by the turf beds being covered with marine deposits. These contain the same kind of shells as do the raised beaches on the opposite coasts of Skäne, namely, *Cardium edule*, *Mytilus edulis*, and *Tellina balthica*, and where the water is deeper and salter *Litorina litorea* and *Nassa reticulata* (Sveriges Geologi, p. 277).

A submarine forest has been reported from the south of the island of Bornholm. Similar evidences are also forthcoming from the district further south; thus, according to Dr. Maack the remains of the Schleiermünder Burg on the coast of Schleswig-Holstein are now always submerged by the sea, and the ancient Bramhorst near Probstei has disappeared; the stumps of the trees forming the forest of this ancient shooting lodge are now to be found under the sea at a distance of 400 or 500 feet from the shore, and two great rocks near Travemünde called Krüger and Möwenstein, which were on the shore 90 years ago, are now surrounded with water. Nilsson, in fact, concludes from these and other observations that Scania and

Mecklenburg were once united by a land-bridge, and it was over this that the animals whose remains are now found in the bogs of Scania crossed over (Comptes Rendus Prehistoric Congress at Copenhagen, 1875, pp. 53–61).[1]

In addition to other evidence of the land-bridge such as is here quoted Erdmann refers to the fact that in the whole of the South of Sweden from the southern coast of Scania, as far as Halland and Smäland, the country is entirely covered with angular débris and contains neither rolled pebbles nor clays except on the eastern and western coast, whence he argues that it was never under water, and he continues:—"Une forte part du continent scanien était, selon toute probabilité, réunie alors avec les îles danoises et les plaines actuelles de l'Allemagne du nord, et il existait de la sorte un pont naturel sur lequel pouvaient immigrer, du grand continent européen, les espèces animales dont nous trouvons de temps à autre les squelettes dans cette province de l'extrême sud de notre pays. La découverte faite par Nilsson des restes de ces animaux dans le sol scanien, faisait déjà présumer, il y a long temps, à ce savant célèbre, la presence, dans les temps reculés, d'un pont naturel entre la Suède méridionale et le continent. Mais, autant que je sache, le fait même que, dans cette partie de la Scanie, les dépôts glaciaires consistent presque exclusivement de glacier anguleux et qu'ils sont par conséquent d'une formation continentale décidée, n'a jamais été remarqué jusqu'ici, et encore moins la conclusion que l'on en peut tirer" (Erdmann, "Exposé des formations Quaternaires de la Suède," pp. 73, 74).

There is abundant direct evidence, therefore, of the former existence of a land-bridge between Skäne and the mainland of Denmark and Mecklenburg, the breaking through of which converted the fresh-water *Ancylus* sea into the salt-water *Litorina* sea. The next question is when did this breach occur. The Swedish geologists and antiquaries are of one mind that it took place after man had begun to inhabit Sweden and during the so-called Stone age. Of this there is a good deal of interesting evidence.

First let us consider the case of the so-called Jära wall. This great rampart, which runs along the sea-coast in the south of Scania from Ystad to a league beyond Trelleborg is essentially an *ås*, and is composed, like the äsar of Central Sweden with which it has been compared, of sand and rolled gravel. There can be small doubt from the facts mentioned below that (as the Swedish geologists agree) it belongs to the time of the *Litorina* sea and was a product of the *Litorina* age.

Nilsson speaks of a peat bog under the Jära wall having a thickness of 10 feet; 2 ft. 3 ins. of which lies above and 7 ft. 7 ins. below the surface of the sea. The turf under this ridge is so compressed that when dry it is almost as hard as brown coal pressed together, and when a fir chip is broken it is found to be black and shining in the cross sections, all the results of great pressure and of age. The turf has been, as in the submarine peat bogs which lie outside Falsterbo already mentioned, formed in fresh water. The bottom of it, when the turf was formed, lay above the surface of the sea, inasmuch as in it were found the same species of plants as those that are found in the other Scanian peat bogs situated farther in the interior of the country. At the bottom of this peat bog, on the pure blue clay itself, there have frequently during the cutting of the turf been found arrows, knives, etc., of flint, which he urges proves that human beings already existed in these districts at the time when the bog was an open water and peat began to grow in it. Consequently there were people here even before the great phenomenon which raised the ridge in question, and caused a wide opening between the South of Scandinavia and the North of Germany.

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[1] This may be the same submerged forest mentioned by Forchhammer, who says it is situated between the island of Römöe and the dukedom of Slesvig, and that it is nine feet below high-water mark, and that its roots are still seen branching out into the sand. The fishermen say this forest consisted of fir. At other places far beyond the present shore forests of oak are found in the same situation below the mean level of the sea (Geol. Trans., ser. II, vi, 157–160).

Bones of the cave bear have been found in the turf under the Jära wall, and also at the bottom of other peat bogs, with bones of the reindeer—for instance, in the peat bog in Kullaberg, in which flint flakes have also been found in great numbers. We may therefore suppose that these peat bogs are coeval with the one under the Jära wall, and, consequently, they also are more ancient than this remarkable ridge. In these ancient peat bogs there has never been found a trace of metal, and therefore we can likewise conclude that the above-mentioned cataclysm took place during the Stone period, and during an early part of the Stone period, since not a single stone axe or any other ground stone was found there, but only flint flakes, arrows, and knives. No human skeletons have occurred in these beds, but inasmuch as round skulls have been found in the old peat bogs of Scania the flint flakes, etc., were probably made by a round-headed race.

In a paper on the Jära wall, etc., Torell, in the Comptes Rendus of the Int. Cong. of Arch. at Stockholm, pp. 867–868, calls attention to the fact that Nilsson had subsequently found a chambered tomb of the Stone age containing amber, on the Jära wall itself, and this goes to show that the famous rampart in question was formed between the time when the rough flint chips were used, i.e. the so-called kitchen midden time and that of the later Stone age.

The facts that Nathorst has since found marine shells of the *Litorina* time underlying the Jära wall, while Munthe, in vol. ii of the Transactions of the Upsala Institute, p. 363, reports the finding of a bone implement in *Ancylus* clay at Norsholm in Ostro-Gothland, show respectively that man was living in Sweden in the *Ancylus* time, and therefore before the Baltic breach; and, secondly, that the Jära wall was distinctly a product of the succeeding period, namely, of the *Litorina* age.

In 1856 Forchhammer contributed a paper to the Nordisk Universitets Tidskrift, in which he enlarged considerably on Nilsson's and Erdmann's conclusions. He pointed out how at

Husum in a submarine peat bog, or immediately under the same, there was found a grave mound dating from the Stone age, and also in other places flint knives and pieces of burnt clay dating from the Stone age. Among the plants from this submarine turf he mentions birch, oak, spruce, and hazel, but he mentions no beech.

I may further add that similar flint tools to those above mentioned have been found in the ancient submerged forest outside Landskrona, while A. F. Cadson has similarly found flint tools in the submerged oak forest lying 300 to 400 metres outside the present beach at Limhamv.

At Islaby in Bleking, De Geer found a bone weapon a metre deep in a turf moss which was partly under the post-Glacial marine boundary and partly under a marine mud.

Lastly, Lindström found charcoal, together with bits of a fish skeleton, which had obviously come from a human feast, under a post-Glacial beach at Wisby, situated 15 metres above the sea (Nathorst, op. cit., pp. 308 and 309).

I will now turn to another kind of evidence. In J. Petersen's memoir, "Om de Skalbaer molluskers utbr. i de danske have indenfor Skagen," Copenhagen, 1888, p. 86, quoted by De Geer, we are told that he found on the bank called Böchers bank, east of Laeso, at a depth of 25 metres, *Litorina litorea* and other shore shells in a sub-fossil condition. He also found similar shells in a similar condition from 18 to 25 metres deep, between Anholt and Kullen, probably near Stora Middelgrund, and De Geer argues thence that the sea-bottom there was once at least 20 metres higher than at present, and that Anholt and Laeso were probably then connected with the mainland of Denmark (Geol. För. i Stockholm Förh., xii, 107).

The case seems, in fact, complete for those who urge not only that the proved succession of the fresh-water *Ancylus* sea by the salt-water *Litorina* sea necessitates our postulating the breakdown of a former land barrier between the North Sea and the Baltic, but that such a breach is amply attested by evidence of every kind, and further that it occurred comparatively lately, and probably during the so-called Neolithic age.

The next question that arises is one in which I cannot see quite eye to eye with the Northern geologists. Like their contemporaries in England, they are devoted to what I deem the quite fantastic development of Lyell's theory of Uniformity which now widely prevails, and they have consequently argued that the breach in question was a gradual and continuous one, due to the wearing away of the banks of the Sound and the Belts by the sea. To this view I cannot in any way subscribe. It seems plain to me that instead of this movement having been gradual and continuous, it was impetuous and rapid and even sudden.

In the first place there is everywhere a distinct gap between the *Ancylus* beds and the *Litorina* beds. Wherever they occur together there is an absolute failure of continuity between them. Nowhere, so far as I know, have we any mixture of the typical fresh-water shells of the *Ancylus* time with the typical brackish-water shells of the *Litorina* time. The latter series of shells follows abruptly upon the former, and this abruptness seems to me to inevitably point to an abrupt breach in the conditions.

Secondly, the condition of the submerged peat bogs and of shallow-water beach gravels in deep water are quite inconsistent with a gradual denudation by which the coastline was eaten back. Such a process of gradual eating back would have entirely destroyed the peat bogs and disintegrated and dispersed the submarine sunken beach pebbles; the pounding and grinding of the shingle on exposed shores would not leave great stretches of peat with enclosed trunks of trees with masses of dead leaves, twigs, etc., lying in great slabs. The existence of these submerged peat-beds occurring in this fashion and of their contents unweathered and unworn, points to their having subsided rapidly or suddenly, so that they could not be acted upon by the tide, but remained safe and unweathered at depths where the sea does not erode.

Thirdly, if the opening of the land-bridge which once limited the fresh-water *Ancylus* lake had been gradual, we should have had a gradual addition of salinity to the Baltic waters until it reached a certain normal amount, when it would have become more or less stationary and not a culmination of the salinity at the inception of the *Litorina* stage and the gradual sweetening of its waters since. The high grade of salinity at the beginning of the *Litorina* time and its gradual declension since, is hardly explainable except as the result of a sudden inpouring of salt water due to a sudden or very rapid breakdown of the land-bridge.

Again, there is direct evidence that since the so-called Neolithic age there have been some cataclysmic phenomena which have caused considerable movements of water in this part of the Baltic. To one of these inundations some inquirers have given the name of the Cimbrian flood, and they have associated it with the well-known passage in Ammianus Marcellinus in which he says, "The Druids affirm that the inhabitants poured in from the islands on the coast and from the districts beyond the Rhine, having been driven from their former abodes by frequent wars, and sometimes by inroads of the tempestuous sea" (op. cit., xv, ch. 9).

More directly geological evidence of a similar fact is forthcoming. Thus, Forchhammer says that on the islands west of Sleswig traces of an inundation may be found to the great height of about 60 feet above the present high-water mark, which happened while the islands were inhabited by man, because we find tumuli partially destroyed by the inundation. The effect and height of this flood may easily be traced by a bed of pebbles, partly rounded, partly angular, containing now and then fragments of bricks, and easily distinguished from a beach by its occurrence in one single bed hardly a foot thick, undulating with the surface, and in one place found only a few feet above high-water mark, while at others it is about 50 feet above it. He considers it as the washing away of the finer materials, or the sand and sandy clay (Forchhammer, Geol. Trans., ser. II, vi, 160).

The existence of the great äs on the seaboard of Scania called the

Jära wall, already described, which overlies deposits containing objects of the Stone age and remains of Pleistocene beasts, and belongs therefore to the *Litorina* time, is another proof that the coming in of that period was accompanied by some cataclysm involving a great rush of water. Those who have attributed this great mound and rampart to the ordinary operations of the tide have surely entirely given up induction in their pursuit of the fantastic type of the doctrine of Uniformity, which is so fashionable and so entirely metaphysical. Nilsson, who was the first scientific man to critically explore the Jära wall, and who first really explained its history, was most emphatic that it was no result of slow secular movements of the sea, but of a cataclysm on a great scale, probably coincident with the first inrush of the salt water to the Baltic on the breakdown of the land-bridge.

Turning from this great äs of Southern Sweden to the äsar of Central Sweden and of the islands on the coast of Esthland, whose upper beds are in some cases full of the débris of the *Litorina* sea, we are constrained to the same conclusion.

The äs at Enköping is a typical instance of an äs in which the upper layers are intercalated with beds containing shells dating from the *Litorina* time. They occur chiefly along the portion of the äs extending from the church to the tilery, which runs from about 102 to 130 feet in height. The richest deposits of shells of the beds occur on the south-eastern slope of the äs, and at one place a bed several feet thick occurs which is almost entirely composed of broken shells of *Mytilus edulis* and *Tellina balthica*. This south-eastern slope has an angle of from 20 to 25 degrees, and its upper layers consist in descending order of—

	Feet.
Gravel with rolled pebbles	2·5
A bed of shells very argillaceous	3·0
Sand and gravel with a few rolled pebbles	1·0
Clay without shells	0·5
Sand and gravel with a few rolled pebbles	1·0
Shelly gravel	0·3
Sand and gravel with a few rolled stones	1·0
Clay (styled glacial) without shells	0·5
Sand and gravel with rolled stones	3·5
Sand as far as the bottom of the trial pit	10·0

On the north-west or opposite slope of the äs the beds were—

	Feet.
Fine gravel	1·0
Shelly gravel (chiefly with *Mytilus*)	0·3
Fine gravel	0·5
Shelly gravel without clay	0·2
Fine gravel	0·3
Shelly gravel without clay	0·7
Fine stratified sand	3·0
So-called glacial clay with threads of sand ...	5·6
Sand	6·0

The äs is traversed by a valley leading from the tilery to the plain from north-east to south-west, which is covered with typical black clay containing *Mytilus edulis*, and in its upper layers is filled with vegetable débris of different kinds, as for example branches of *Equisetum limosum* mixed with fragments of conifers and leaves of the oak, willow, and poplar, needles and cones of *Pinus sylvestris*, cones, branches, and bark of the fir (*Abies*) and the poplar, remains of a *Sparganium* with leaves of grass, of *Ledium palustre*, etc. Erdmann argues that the *Equisetum* lived at the margin of the water, but that the other débris were transported by running water ("Exposé des formations," etc., pp. 95 and 96).

These facts seem to me to point to some interesting results. It is probable that the shells are not all *in sitû* on the äs. They are fragmentary and transported. Nor is it quite easy to see how they could well have lived on the two slopes of the äs, which rises like a rampart from the adjoining low country, and in no way forms, or could ever have formed, a boundary to the sea. The shells in question are distinctly shore shells, and could hardly again, have lived both on the top of the äs and also at the bottom of the valley cutting through it, where they are also found, at the same time, and the question may well be raised whether these upper beds can be explained by any other process than a cataclysm, and whether, as in the case of the Jära wall, they were not laid down in a violent way at the time when the bridge was broken down separating the outer sea from the great *Ancylus* lake, when a great inrush of water must have taken place. This seems to be the only way of accounting for the facts, which will also account for the finding of many very large erratics on the crests of some of the shell-bearing äsar, which must have needed some gigantic force to move them.

It seems quite preposterous in this case to appeal to ice-portage, for the climate of the country during all the *Litorina* time was, as we shall see in a later paper, as mild or even milder than it is now. Apart from this there are not, and never could have been, icebergs in the Baltic, certainly not at a time when the present flora occupied the land. The only ice available would be shore ice, but shore ice is only found and only acts on sea-beaches. It cannot reach up to 150 feet above the water-level, which is the height of this äs. If the äs was already there when the shells and also the boulders were deposited, there can be no question of its having been there as a beach barrier. The fact of the shells occurring on both slopes forbids such a notion, as does the whole arrangement of the beds in the huge mound. Nowhere that we know of are beach ramparts being formed in the fashion of these äsar. Anyone who will visit them and tramp over them for miles, as I have done, and sit upon and contemplate the size of the erratics on their back, and the conditions and surroundings, physical and biological, in which they occur, and who still pleads for ice as the transporter of the stones which lie in and on their current-bedded sands and gravels with such shells as *Mytilus* and *Cardium*, seems to me to have abandoned science for romance and metaphysics, and this may even be the case with some prominent and very confident advocates of what is called moderate glacialism.

I propose to return to the question in another paper. Meanwhile let me support the position I am maintaining by an appeal to two of my old masters, whom I have tried to imitate at least in one respect, namely, by a patient and laborious exploration of these äsar on the spot, and not in the method by which the German philosopher made his camel.

First, Murchison, who had no doubt about the äsar having been the products of aqueous and not of ice action. Murchison refers to the shells of the Baltic Sea as previously mentioned by Lyell as occurring in a blue clay beneath the great mass of äsar drift, indicating in the clearest manner a submarine condition when the drift was transported (Q.J.G.S., iii, p. 365). Again, he says, "In the sandy and gravelly beds of the äs on which the castle of Upsala stands Mr. Macklin found several species of shells, including the *Tellina balthica*; other argillaceous beds of blue clay which occupy the banks of the river, on either side of which the äsar rise up, are also in some spots absolutely loaded with this shell, showing that the whole base of the soft and overlying formations is truly of aqueous origin of no very distant date, the shells being specifically the same as those now living in the adjacent Baltic and exhibiting their nacre perfectly preserved" (id., p. 369).

Lyell in describing the äsar of Sweden says they were certainly produced under the sea. They usually consist of stratified sand and gravel, the layers being often at high inclinations, but where they are composed of boulders no stratification is observable. After a long search he says he found shells in a layer of marl in a ridge near Upsala, about 12 feet below the summit of the ridge and 80 above the sea. The shells are the commonest now in the Baltic. On the summit of the ridge he noticed angular masses of gneiss and granite from 9 to 16 feet long, *which had evidently been lodged when the ridge was submarine.*

Elsewhere he speaks more definitely.

"In Sweden," he says, "in the immediate neighbourhood of Upsala, I observed in 1834 a ridge of stratified sand and gravel, in the midst of which occurs a layer of marl, evidently formed originally at the bottom of the Baltic by the slow growth of the mussel, cockle, and other marine shells of living species intermixed with some proper to fresh water. The marine shells are all of dwarfish size, like those now inhabiting the brackish waters of the Baltic; and the marl, in which myriads of them are embedded, is now raised more than a hundred feet above the level of the Gulf of Bothnia. Upon the top of this ridge (one of those called osars in Sweden) repose several huge erratics, consisting of gneiss, for the most part unrounded, from 9 to 16 feet in diameter, and which must have been brought into their present position since the time when the neighbouring gulf was already characterized by its peculiar fauna. Here, therefore, we have proof that the transport of erratics continued to take place, not merely when the sea was inhabited by the existing testacea, but when the North of Europe had already assumed that remarkable feature of its physical geography which separates the Baltic from the North Sea, and causes the Gulf of

Bothnia to have only one-fourth of the saltness belonging to the ocean.

"I cannot doubt that these large erratics of Upsala were brought into their present position during the recent period . . . The Upsala erratics may belong to nearly the same era as the refuse heaps (i.e. the Danish kitchen middens)." ("Antiquity of Man," pp. 281–2.)

This is a remarkable conclusion for a man of Lyell's views to have arrived at, and it clearly shows that in his view the äsar, or some of them, actually dated from so recent a time as the Neolithic age, when the climate of Northern Europe was milder than it is now, and when ice-portage, as necessitated by the glacialists' theories about these and similar erratics, are quite out of court.

I quote it as showing that Lyell had no hesitation in attributing the formation of the äsar and the distribution of the enormous erratics which crowd their backs to the action of water, and not to that of ice, a fact for which I have made a vigorous fight in my work recently published. It seems to me, however, that the water we must appeal to in such a case is not the sea in its normal moods, but the sea when under the influence of some cataclysmic impulse such as I have shown to have probably initiated the *Litorina* stage of the history of the Baltic. If this is to be appealed to as the fashioner of the äsar it may be that we have been too sanguine in treating all the more recent raised shell-beds in the Baltic area as measures and indices of the former permanent level of the sea, and that they may rather mark the level at which the huge tide caused by the breach in the old land-bridge deposited its load of débris. I may revert to this issue in another paper.

EXPLANATION OF PLATE XIX.

I.

Map of the Baltic as it is now and as it was at the maximum limit of the *Litorina* Sea. After De Geer. Nathorst, Sveriges Geologie, p. 267.

II.

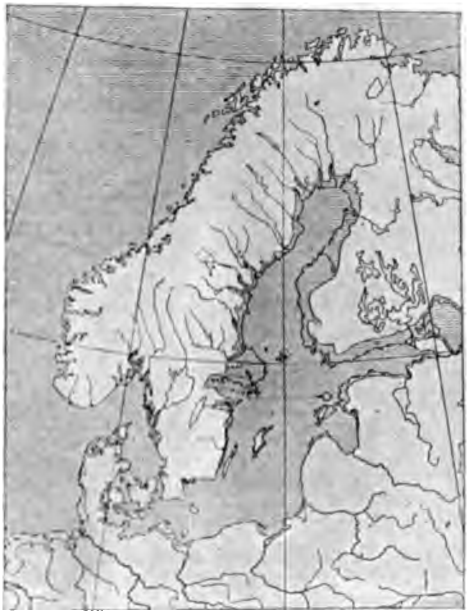
FIG. 1. *Cardium edule* (dwarfed form) from Gotland.
,, 2. *Cardium edule* (normal growth, natural size) from the Cattegat.
,, 3. *Tellina balthica* (dwarfed form) from the äs at Enköping.
,, 4. *Litorina litorea* (dwarfed form) ,, ,,
,, 5. *Litorina litorea* (normal growth, natural size) from the Cattegat.
,, 6. *Paludinella balthica* (dwarfed form) from Gotland.
(See Nathorst, Sveriges Geologie, p. 270.)

Figs. 2 and 5 give the normal growth of *Cardium* and *Litorina* and their natural size at the Cattegat, where they enjoy the full amount of salt water. Figs. 1 and 4 show the same species of shells from Gotland and Enköping, dwarfed by the decreased salinity of the waters as one recedes from the ocean towards the inner recesses of the Baltic. The *Tellina*, Fig. 3, is a similarly dwarfed variety; but Fig. 6, *Paludinella*, a fresh or brackish water shell, owes its degeneracy to too saline conditions.

ERRATA IN THE PREVIOUS PAPER.

Page 311, line 8; 317, l. 42; 318, l. 38; and 320, l. 9, *for* De Geers *read* De Geer.
Page 314, l. 29, after *balthica*, insert *Scrobicularia piperata*.
Page 318, l. 10, *for* which *read* what; and l. 17, *for* wash *read* mark.
Page 319, lines 1 and 16, *for* Lomberg *read* Lönnberg; and l. 40, *for* has *read* have.

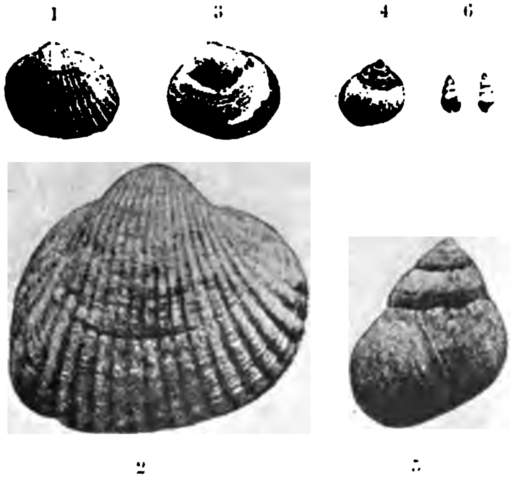
I.



THE BALTIC

it is now and as it was at the maximum limit of the Litorina Sea. After De Geer. Nathorst, Sveriges Geologie, p. 267.

II.



THE BALTIC SHELLS.

s. 2 and 5, shells from the Cattegat. Figs. 1, 3, and 4, dwarfed by excess of *water in the interior* of the Baltic (see Explanation of Plate, p. 352).

II.—The Lower Carboniferous Problem in Devonshire.

By A. J. Jukes-Browne, B.A., F.G.S.

WHAT represents the Carboniferous Limestone in Devonshire, is a question that has often been asked, but has never yet een answered in a satisfactory manner. The question has recently een narrowed by the identification of the Coddon Hill Beds and he *Posidonomya* limestones with the shales, cherts, and limestones which overlie the mass of the Carboniferous Limestone in South Wales,[1] and with the Pendleside Beds which occupy a similar osition in Staffordshire, Derbyshire, and South Yorkshire.[2] Dr. W. Hind considers these beds to be more intimately connected with the Upper than with the Lower Carboniferous Series, and in any case he homotaxial equivalent of the main mass of the Carboniferous Limestone must be sought for below them.

If the upward succession from the Pilton Beds be continuous and unbroken—and there is good reason to believe that it is so near Barnstaple and again near Bampton—the question has now been narrowed down into small limits; for the whole Lower Carboniferous Series must in that case be represented either solely by the narrow band of dark shales (Fremington Beds) which intervenes between he Pilton Beds and the chert beds of Coddon Hill, or else by hese shales together with a certain portion of the Pilton Beds. Further research may reveal a purely Carboniferous fauna in the higher part of the latter, but hitherto no such exclusively Carboniferous assemblage has been found in them, and the problem, so far as North Devon is concerned, remains as much of a puzzle as ever.

Hitherto, however, the problem has always been attacked by comparing the succession in North Devon with that of areas further north, and endeavouring to find equivalents for the limestones and shales of the Lower Carboniferous Series which have so great a development over both England and Ireland. In other words, it has been tacitly assumed that this series must not only be represented in Devon, but that the thickness of its representative must be comparable to that of the more northern facies, whether that of the Bristol area, or of South Wales, or of the south of Ireland. This assumption involves the further supposition that the Carboniferous sea continued to be as deep or even deeper to the southward than it was along the latitude of South Wales and South Ireland, so as to allow of the deposition of a similar thickness of sediment.

These assumptions may have hindered the solution of the problem, and it has occurred to me that it might be profitable to approach the question from the south; for if the representative of the Lower Carboniferous Series on the southern side of the great Culm-measure trough is as feeble as it seems to be on the northern side, and if we can find any clue to the explanation of this phenomenon in the south, it may be applicable to the northern area.

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[1] See Summary Prog. Geol. Survey for 1900, p. 87.

[2] By Dr. Wheelton Hind in Geol. Mag., Dec. V, Vol. I, p. 392 (1904).

There is also this advantage, that the surveys and researches made by Mr. Ussher have established the Devono-Carboniferous succession in South Devon and North Cornwall, which was formerly such a doubtful matter. It now appears that in this area there is a much more concentrated type of Upper Devonian, consisting mainly of slates with interbedded volcanic rocks, and that its total thickness is much less than in North Devon, so that there is less doubt about the delimitation of the Devonian and Carboniferous systems. It is true that the actual passage from one formation to the other has not yet been recognised in section, but the limits within which the transition may lie are much narrower.

On the other hand, Mr. Ussher's work has shown that the succession of the Lower Culm Series in South Devon is similar to that in North Devon, being as follows:—

4. Dark shales and mudstones with occasional limestones (Posidonomya Beds).
3. Hard cherty shales and chert beds (Coddon Hill Beds).
2. Hard dark mudstones.
1. Dark grey shales.

The beds below the cherty group are well developed near Ashton and Trusham on the north-east side of Dartmoor, and are probably part of the normal succession along the northern and western portions of the area, but are seldom seen in actual infra-position to the chert beds. The beds are everywhere so flexured and faulted that Mr. Ussher has never yet ventured to publish any estimate of their thickness. It can, however, be easily gathered from his published descriptions of them that the thickness is relatively small, and in response to my earnest request for some approximate idea of their probable thickness he has kindly informed me that he thinks the Posidonomya Beds may attain 150 feet, that the chert beds and the hard mudstones below may attain 150 feet, and that he has never seen more than 25 feet of the basal dark shales, though it is quite possible that they have a thickness of 50 feet or more. He also tells me that although he has separated the 'hard mudstones' which underlie the chert beds, yet it is quite possible that they contain Radiolaria and belong to the Chert Bed group.

Mr. Ussher also wishes me to say that the statement of possible thickness is merely an expression of the probabilities of the case as impressed upon him by experience in the field. That, however, is all that is necessary for the object of this communication, and my readers will understand that the figures are not to be taken as measurements.

Another point of special interest about this southern area is the presence of contemporaneous volcanic rocks both in the Upper Devonian and in the Lower Culm. In the former they are of sporadic or local occurrence, but are specially prevalent to the north of Plymouth. Of this district Mr. Ussher wrote in 1901[1]:—"Contemporaneous igneous rocks occur in the Upper Devonian in the immediate vicinity of the Wearde St. Erney and Efford sandstones, and these igneous rocks correspond to the lower part of the Devono-Carboniferous volcanic group." Again, he says that both near Saltash and Tavistock "volcanic rocks have been proved to occur in the Upper Devonian and throughout the Lower Culm-measures, but not in the middle Culm-measures."[2]

Finally, near Beer Alston, Middle Culm sandstones are found to rest directly on Upper Devonian slates, and to explain this he invokes local unconformity due to the volcanic disturbances in the district, remarking that "it is probable that the upheaval of the sea-bed was so irregular in the volcanic districts that Middle Culm-measures, elsewhere apparently conformable to the Lower Culm-measures (as regards position), were partly formed by denudation of the Lower Culm-measures, and so rest on Upper Devonian rocks."

The existence of volcanic rocks interbedded with the Lower Culm-measures has been known for many years; they have been described by Mr. Rutley,[3] who seems to have thought that Brent Tor was the principal volcanic vent, and that it might have formed a volcanic island in the Carboniferous sea. Similar rocks (tuffs, schalsteins, diabase, and dolerite) occur throughout the range of the Lower Culm, from Launceston on the west to Oakhampton and Belston on the east, and again still further east in the Ashton and Trusham district, where there is a marked development of tuffs and dolerites in the group that contains the Chert-beds. These intercalations are shown on Sheet 339 of the Geological Survey Map (new series).

From the passages above quoted, and from others which might be given, it is clear that Mr. Ussher connects the volcanic disturbances and eruptions with "a general elevation of the sea-bed either after or during the deposition of the Lower Culm rocks,"[4] and the production of a local discordance near St. Mellion. In this view he is very likely to be correct, for it is well known that upheaval is a frequent accompaniment of volcanic activity; but it seems to me that the supposition of such a movement will explain much more than a mere local unconformity. It will surely explain the small thickness and the character of the deposits which constitute the Upper Devonian and the Lower Culm-measures in South Devon.

With regard to the Upper Devonian the notable absence of grits or sandstones seems to indicate that the area of deposition was at some distance from any large area of land, while the small, sporadic, and lenticular developments of limestone show that the conditions were not favourable for the growth of calcareous organisms. When compared with the Upper Devonian series of North Devon the natural inference is that the southern area was one in which the process of deposition of sediment went on slowly.

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[1] Trans. Inst. Mining Eng., vol. xx, p. 9 of reprint.

[2] The Wearde sandstones and associated volcanic rocks are now included in the Upper Devonian.

[3] Quart. Journ. Geol. Soc., vol. xxxvi, p. 284.

[4] Proc. Som. Arch. and Nat. Hist. Soc., vol. xlvi, p. 51 of reprint.

This slowness of deposition is still more marked in the case of the Lower Culm, for if Dr. W. Hind is right in correlating the Posidonomya Beds and the Chert-beds with the Pendleside Series, there remains very little indeed to represent the Carboniferous Limestone Series; merely some dark shales which may be 50 or perhaps 100 feet thick.

Now if we assume that the whole area of sea-floor on which these deposits were successively formed was being more or less rapidly raised as a consequence of volcanic disturbance, and that submarine vents were opened from which lava and ashes were ejected, have we not a sufficient explanation of the facts? On a submarine area lying at some distance from land and undergoing upheaval only a small thickness of sediment could accumulate; in the vicinity of active volcanic vents animal life could not continually flourish on the sea-floor, and consequently limestones would either be thin and sporadic as in the Upper Devonian, or entirely absent as in the basal beds of the Culm.

In South Devon, therefore, it would seem that not only have we to accept the fact that there is very little to represent the Lower Carboniferous Series, but we are furnished with a good and sufficient reason for a fact which would otherwise be very difficult to explain.

Applying the lesson thus learnt in South Devon to the problem which has so long exercised the minds of geologists in North Devon, it is evident that we may have to accept as a fact the absence of any commensurate equivalent of the Carboniferous Limestone Series; for even if it should turn out that some part of the Pilton Beds are of Carboniferous age, yet it is not likely that any great thickness of such beds can come in between those which contain a Devonian fauna and the Fremington Beds.

It may be said that there is no evidence of volcanic activity in North Devon either during Upper Devonian or Lower Culm time. So far as we know at present there is little evidence of it, but there is intrusive felsite at Bittadon near the junction of the Morte Slates and the Pickwell Down Beds, and similar rock was traversed in the Button Wood cutting on the Barnstaple and Lynton Railway.[1] This felsite was described by Professor Bonney in 1871,[2] and regarded by him as probably of late Devonian age, but it may with equal probability be referred to the Lower Carboniferous, for, as Professor Bonney pointed out, the only clue to its age is the fact of its being cleaved, which proves the intrusion to be "prior to the close of the Carboniferous Period." Another dyke of intrusive igneous rock (apparently basalt) occurs in the Fremington Beds near Fremington, and Mr. Hamling informs me that it is not far from the passage to the Lower Culm; a little further south is a boss of grey felspathic rock, the relations of which are more obscure.

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[1] Summary of Prog. Geol. Survey for 1897.

[2] Geol. Mag., Dec. II, Vol. V, p. 207.

But even if there were no active vents in the northern area we must remember that the distance between the two areas is not great. The tract of Lower Culm at and near Bampton is only 24 miles north of Ashton, and Coddon Hill is only about the same distance from the northern border of Dartmoor, so that if the southern area was being elevated and shallowed the northern area could hardly fail to partake in the upward movement to some extent.

The great thickness of the Upper Devonian in North Devon does indeed seem to indicate that no upward movement was in progress there during the process of its formation, and in this connection we must remember that we have no proof of upheaval at this time in South Devon, only the association of volcanic rocks. The actual uplift may not have taken place until the beginning of Carboniferous time, for it is only in the Lower Culm that evidence of erosion occurs, and it is the Lower Carboniferous rocks which are apparently so thin both in South and North Devon.

The probability of the suggested upheaval and erosion in South Devon is increased by the fact that in Brittany (still further south) there is a decided break between the Devonian and the Carboniferous. In that region the oldest Carboniferous rocks are conglomerates, sandstones, and volcanic rocks, which lie unconformably upon the Middle Devonian, both in the basin of Chateaulin and in that of Laval. These are succeeded by slates with occasional limestones, which seem to represent the Viséan or upper part of our Limestone Series.[1]

In conclusion, I may observe that I should not regard the existence of Radiolaria in the chert-beds as constituting a difficulty in the way of my suggestion, for I dissent from the view that Radiolarian cherts are by themselves any proof of deep water. Mr. L. Cayeux has shown that siliceous deposits containing Radiolaria occur in the Oxfordian of the Ardennes, in the Gaize de l'Argonne, in the Smectique de Herve (Belgium), and in the Lower Eocene tuffeaux of France and Belgium. None of these can be regarded as specially deep-water deposits, while the last occurs in sands of the age of our Thanet Beds, and yet is very rich in Radiolaria.[2]

It is evident from these facts that other proofs than the mere occurrence of Radiolaria are required before the supposition of very deep water or oceanic conditions can be accepted. Such proofs are not forthcoming in the case of the Culm chert-beds, for, as I have remarked elsewhere,[3] the beds associated with them are not comparable in any way to the oceanic deposits of the present day. So far as we can judge, Radiolarian deposits are more indicative of conditions which do not favour the existence or the preservation of the remains of calcareous organisms than of any special depth of water.

Finally, the fact of the occurrence of similar cherts containing

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[1] See de Lapparent's Traité de Géologie, 4th ed., p. 895, and references.

[2] Contrib. à l'étude micro. des terr. sédim.: Mem. Soc. Géol. Nord, tom. iv, Lille, 1897.

[3] Stratigraphical Geology, p. 269, Stanford (1901).

Radiolaria in South Wales between the Carboniferous Limestone and the Millstone Grit proves that conditions suitable for their formation occurred at no great distance from Carboniferous land, and goes far to disprove the view put forward by Messrs. Hinde and Fox that the Lower Culm beds of Devonshire are "deep-water representatives of the shallower-formed calcareous deposits to the north of them."[1]

III.—A WIND-WORN PEBBLE IN BOULDER CLAY.

By Dr. F. A. BATHER, M.A., F.G.S., British Museum (Natural History).

NEARLY forty years ago Mr. R. D. Darbishire obtained from the Glacial gravel of Bowdon, Cheshire, a facetted pebble, which I afterwards had the privilege of describing (Proc. Geol. Assoc., xvi, pp. 396–420, pl. xi, June, 1900). The conclusion then reached was that the pebble bore witness to the action of blown sand at a period during or not long before the deposition of that particular bed of Glacial Drift. Since, however, the pebble was in other respects similar to pebbles common in the Bunter beds, and since some had supposed the existence of desert conditions in those Triassic times, there remained the possibility, and to some minds the probability, that the pebble in question had received its facets during the Triassic epoch. It may, therefore, be useful to draw attention to a distinctly facetted pebble from the Boulder Clay within twenty-five miles of Bowdon. This was found by Mr. W. D. Brown, of Burscough (north-west of Ormskirk, Lancashire), at about three feet below the surface in the Burscough Brick Company's clay pit. The pebble is composed of a greyish micaceous sandstone, weathering yellow, and too coarse and loose in texture to be capable of taking a polish. The facets on it, however, are clearly cut, and do not appear to have undergone much, if any, subsequent abrasion. Its greatest length is 37·5 mm.; greatest width, 29·5 mm.; greatest thickness, 7·9 mm. What was probably its uppermost surface, during the latest period of its exposure to wind action, shows a flat central area, of irregularly pentagonal outline, surrounded by five facets, of which one is slightly concave, one rather irregular, two slightly convex, and the last markedly convex and probably retaining the original curved surface of the pebble. The greater part of the under side seems to preserve the original rounded, presumably water-worn, shape, but about two-thirds of this side is bevelled at an angle of about 45° by two facets which are not clearly separated from one another. The number of facets on the upper side suggests that the stone was, perhaps more than once, shifted round its vertical axis, while the under side indicates that it was at one time blown over into a different position of equilibrium. Nothing, however, would be gained by further speculation: the real value of the find seems to lie in its confirmation of the view that abrasion by blown sand did take place in the north-west of England during the later Glacial age. Mr. Brown tells me that he found another facetted pebble in the clay of the same pit. Possibly, therefore, wind action was not rare; its traces may even prove sufficiently common to warrant the inference that steppe-like conditions then extended to those parts of the country. The other evidence in favour of that view need not be repeated here; but it should be borne in mind, for, as pointed out in my previous paper (p. 415), what is good proof of wind abrasion is not in itself a necessary proof of steppe or desert conditions.

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[1] Quart. Journ. Geol. Soc., vol. li, p. 609 (1895).

The pebble herein described remains in Mr. Brown's collection, but he has kindly allowed the Geological Department of the British Museum to take plaster casts of it. For this, and for his courtesy in submitting the specimen to me, he has my sincere thanks.

IV.—THE RHODESIAN BANKET BEDS.

By F. P. MENNELL, F.G.S., Curator of the Rhodesia Museum, Bulawayo.

I. *Introduction.*

WHAT are popularly termed the Banket Beds of Johannesburg have for years past been justly celebrated for their extraordinarily large and steady gold production. Their literature has already assumed formidable dimensions, so it is unnecessary for my present purpose to give a detailed account of the features they present. They form part of what is generally known as the Witwatersrand Series, which consists of highly altered sandstones and conglomerates almost certainly of Archæan age.[1] They unconformably overlie the banded rocks known as the Hospital Hill Beds, and are overlain by the Dolomite, often termed the 'Olifants Klip' or 'Elephant Rock.'

The gold in the Rand banket is not found in independent veins or reefs. It is confined to a few more or less constant horizons (universally but erroneously termed 'reefs') in the rock itself, but at the same time the latter is highly impregnated with silica and pyrites, and it is these cementing materials, principally the pyrites, which carry the gold, while the pebbles are practically non-auriferous. It thus appears that the absence of true veins is due to the ease with which solutions could spread through the originally incoherent gravelly material, instead of their flow being confined to cracks and fissures. The constancy of horizon may therefore be attributed merely to the localization of precipitants. It is certainly not due to the gold being detrital like the other materials of the rock: regarded as ore deposits the Rand veinstones are in no sense 'alluvial.'

II. *The Old Rhodesian Conglomerates.*

I first drew attention to the occurrence of conglomerates among the presumably Archæan rocks round Bulawayo in the Rhodesia

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[1] See discussion of age and correlation, Geol. S. Rhodesia, pp. 20–25.

Museum Report for 1902. Since then further investigation has shown how widespread is their distribution throughout the country, and has yielded much evidence as to their origin, lithological characters, and stratigraphical position, the discovery of gold in the Lomagundi district having been instrumental in promoting an active search for the rock in nearly all the mining districts.

In view of the fact that specimens have been submitted to experts outside the country, who have been disposed to favour the idea that the rock is a 'crush-conglomerate' rather than an altered sediment, it may be as well to at once state the evidence against such a view. The internal evidence of even a good series of specimens is quite sufficient to negative the idea, while no one fully acquainted with the geological features of Rhodesia would ever have given it consideration.

As an Archæan rock, the conglomerate has undergone a considerable amount of alteration. It exhibits the results of shearing and crushing to a marked degree, as well as changes due to the infiltration of secondary minerals. But at the same time its original features are by no means unrecognisable. Thus we find that there is no grading of the pebbles into the surrounding matrix: in spite of crushing and slips they show perfectly well-defined boundaries even in sections under the microscope. More than this, they exhibit the greatest variety of rock types, and often, one may say as a rule, the common types of pebble are quite different in composition to the matrix. Thus, even where quartz and granite fragments are predominant, there is often no quartz in the finer material. There are frequently scarcely any representatives of the surrounding rocks among the pebbles, which comprise on the other hand petrological types nowhere known in Rhodesia at the present day *in situ*. I may instance the fact that a few yards of outcrop near Hopefountain yielded me on a hurried visit the following varieties of pebble: white glassy quartz, dark quartz, banded ironstone, 'halleflinta,' two kinds of chlorite schist, hornblende schist, granite, granophyre, porphyrite, and at least two distinct kinds of amygdaloidal lava. It will be evident from this that the crush theory is by no means strengthened even by such a supposition as the entire breaking down of an igneous intrusion. But it is the stratigraphical evidence which is decisive, and it is unnecessary to dwell on the points already raised in view of the distribution of the conglomerate over the entire country, taken together with its great thickness and its position being always reconcileable with its occupying a constant horizon. The rock is, in fine, precisely what one would expect to result from the denudation of an extensive area of varied igneous and metamorphic rocks. Hard and resistant substances like vein quartz, banded ironstone, granophyre, and halleflinta form most of the pebbles, while the more easily disintegrated granites and schists have usually gone to make up the finer matrix. The ready decomposition of the more basic igneous rocks and hornblende or chlorite schists affords an obvious explanation of the cases where the pebbles are largely quartz, with some granite or granophyre, in a matrix now converted by metamorphism into hornblendic or chloritic schist. And crushing as a mode of formation is obviously inconceivable in the cases, by no means uncommon, where numerous chlorite-schist pebbles occur in a sandy matrix.

III. *Stratigraphical Position.*

In discussing its origin I have already remarked on the constant horizon of the conglomerate. It is the topmost member of the Rhodesian Archæan group, which comprises—

(3) Conglomerate and grits.
(2) Banded ironstone.
(1) Crystalline schists.

The last include the oldest rocks, but also a certain number of recrystallized masses which represent relatively late igneous intrusions. The three groups are unconformable, though they usually exhibit a concordant strike and dip. These, however, are obviously more apparent than real, the dip being that of foliation or cleavage. The banded ironstones, it may be as well to mention, are an enormously thick series of altered sediments, sometimes, though rarely, slaty, but more often highly silicified and jaspery, or consisting almost entirely of limonite, hæmatite, or magnetite. The banding, which is probably a very unsafe indication of bedding, is, however, always to be seen, an alternation of red and white, brown and white, or other dark and light bands being conspicuous in most cases. These rocks are known as Griquatown Beds in Cape Colony and Hospital Hill Beds on the Rand, in which latter locality they unconformably underlie the famous banket. Our conglomerate has thus precisely the same stratigraphical position: it unconformably overlies the banded ironstone and is implicated in most of the later movements of that rock, a corresponding foliation having been impressed upon it. The great granite masses of Rhodesia are intrusive in all the rocks up to and including the conglomerate, and some of the epidiorites, in which the granites are themselves intrusive, are almost certainly the result of the alteration of doleritic intrusions also later than the conglomerate. In any case the conglomerate contains no pebbles derived from them. I think the probabilities—and these are all we have to go upon in any South African correlations—are extremely strong in favour of the Rhodesian conglomerate being the stratigraphical equivalent of the Witwatersrand Beds.

As regards distribution, the only districts where the conglomerate has yet been continuously traced over a large area are those of Bulawayo and Lomagundi. It is, however, known to occur in the Umtali, Abercorn, Mazoe, Hartley, Sebakwe, Selukwe, Victoria, Belingwe, Bubi, and Gwanda districts, that is to say, scattered over an area of fully 100,000 square miles. The thickness of the rock and the associated finer sediments is very variable. Near Bulawayo it is from a few hundred to several thousand feet thick, and it is probable that the average is at least 1,000 feet.

IV. *Economic Importance.*

The geological correspondence of the Rhodesian conglomerates with those of the Rand naturally raises the question of their proving of similar economic importance. As a matter of fact, though it has not been generally recognised, 'banket' has been worked for some time on the Wanderer Mine at Selukwe, a big low-grade deposit at the junction of the conglomerate and the banded ironstone, the latter, however, forming the bulk of the ore. The conglomerate has been tested in numerous other localities, with poor results, and so far it is only at the Eldorado Mine in the Lomagundi district that gold has been proved to exist in payable amount. Recent developments at this locality have shown that not only is the ore in general of very high grade, but that the ore shoot contains occasional patches of phenomenal richness. The conglomerate is here altered and sheared to a greater extent than usual. The matrix has passed into the condition of hornblende schist, and consists of deep-green ragged hornblendes, irregular felspar granules, and some possibly secondary quartz; epidote, biotite, and chlorite being also present in addition to magnetite and pyrites. The pebbles, which are occasionally large enough to be termed boulders, are chiefly of granite or granophyre, considerably altered, but not so much so as to leave any doubt as to their nature. Nearly black quartz is common, and what may possibly be banded ironstone also occurs. Pebbles of white quartz are rare, but many little veins of secondary quartz are seen, sometimes traversing faulted pebbles in a most interesting manner, while there is often a good deal of pyrites. The rich specimens enable the distribution of the gold to be studied with unusual ease. The precious metal is practically confined to the matrix of the conglomerate, and is principally seen in cracks formed after it had assumed its present characters, apart of course from those due to changes resulting from the introduction of the gold itself and that of the other secondary minerals by which it is accompanied. Even where very rich the gold is fine and not nuggety; it is rarely seen in the pebbles. When they do show it, it is always along cracks formed during the extension of the pebbles at right angles to the pressure, or along slipping planes, sometimes with and sometimes without secondary quartz and pyrites. Round the pebbles, and especially at their ends, where slips would tend most to loosen the rock, the gold is often very abundant, forming a regular coating to the pebbles in extreme instances. It is clear that here, as on the Rand, the gold is of secondary origin, and was not present during the original deposition of the rock.

I may conclude by expressing my indebtedness to Dr. H. Sauer for specimens, etc., and for permission to describe the Eldorado rock; to Messrs. J. L. Popham and A. J. C. Molyneux, F.G.S., for specimens and slides; and to Mr. H. E. Jones, A.R.S.M., for some valuable notes and suggestions.

V.—CONTRIBUTIONS TO THE GEOLOGY OF CEYLON:

4. INTRUSIVE PYROXENITES, MICA-PYROXENITES, AND MICA-ROCKS IN THE CHARNOCKITE SERIES OR GRANULITES IN CEYLON.

By ANANDA K. COOMÁRASWÁMY, B.Sc., F.L.S., F.G.S., Director of the Mineralogical Survey of Ceylon.

(PLATE XX, IN TEXT.)

THE object of the present paper is to provide a short account of a group of rocks to which the general name of *pyroxenite* may be given, inasmuch as they are essentially non-felspathic plutonic rocks, free from olivine, and of igneous origin, and with a nearly colourless monoclinic pyroxene as the chief or only constituent of many of the most conspicuous varieties.[1] The exposures are widely distributed in the Central, Uva, and Sabaragamuwa provinces, and probably throughout Ceylon, but are individually of very small extent. The rocks are composed of the minerals diopside, amphibole, phlogopite (or biotite), scapolite, pyrite, sphene, and sometimes felspar, calcite, and spinel; the dominant mineral is the pale green or grey granular diopside, colourless in thin sections: the rocks are often entirely, or almost entirely, composed of this mineral; next in importance are green amphibole (dark in hand-specimens, but very pale in thin sections), and a pale golden-brown phlogopite, which sometimes forms a large proportion of the rock, and in extreme cases the whole bulk of sills or dykes several feet in thickness.

The rocks occur in sills and dykes of all sizes, from a fraction of an inch to six feet or more in thickness, and their intrusive character is generally clear. Very similar or identical rocks occur also as nodular aggregates in crystalline limestones, and also near and along junctions of granulite and crystalline limestone[2]; but for the sake of brevity and clearness, only those occurrences which are less particularly associated with the crystalline limestones are described in the present paper. The pyroxenites are clearly intrusive in the charnockites or granulites; although often occurring in beds or sills following the foliation planes of the granulites, they occur equally or more often as typical dykes crossing these foliation planes, and sometimes occupying joints; the figures illustrate examples of both modes of occurrence, which, moreover, are frequently associated.

This occupation of joints shows that the pyroxenic material must have been introduced after the granulites had sufficiently consolidated to allow of the formation of joints. This fact, together with another, viz., the occurrence of what seems to be a very ordinary mica pyroxene dyke cutting the zircon granite (itself belonging to the Balangoda group,[3] and forming an intrusive sill in the Charnockite Series or granulites) of Massena estate, Balangoda, appears to indicate that the date of the pyroxenite intrusions was long posterior to that of the intrusion and consolidation of the granulites. Nevertheless, careful examination of the junctions shows that there is never any sign of a chilled edge, but the pyroxenic rock passes, rapidly indeed, but never abruptly, into the granulitic rock next to it, and this even where the intrusive character is otherwise most distinct. There is, in fact, a rapid transition from one rock to the other. Inasmuch as the pyroxenites are intrusive in rocks which had cooled sufficiently to allow of the formation of joints, these facts seem to show that re-melting must have taken place to some extent.

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[1] For a discussion of the nomenclature of similar rocks, see C. H. Gordon "On the Pyroxenites of the Grenville Series in Ottawa County, Canada," Journal of Geology, vol. xii, No. 4, 1904, pp. 324, 325.

[2] For descriptions see A. K. Coomáraswámy, "The Crystalline Limestones of Ceylon," Quart. Journ. Geol. Soc., 1902, vol. lviii, pp. 399–422.

[3] A. K. Coomáraswámy, GEOL. MAG., No. 482 (1904), pp. 418–422.

A zoned structure is very characteristic of the rocks, the zoning being marked by the distribution of mica in bands parallel to the edges of the dyke or sill, the individual crystals of mica being disposed in planes perpendicular to the edges of the dyke or sill, which is often symmetrical in structure about a median line, after the manner of mineral veins. The zoned structure is not always produced by mica; in Fig. III, Pl. XX, p. 366, for example, the central darker zone is distinguished by its content of hornblende, and mica is not present.

The pyroxenites seem to be in some way connected both in mineral composition and in actual distribution with the occurrence of crystalline limestones, though the exact relation is not perfectly clear. One curious feature is the presence of carbonates in parts of the dykes, especially at Ella (Uva) and Kadawat Oya (Sab.); when it becomes abundant, the central zone is sometimes indistinguishable from an ordinary crystalline limestone with abundant accessory minerals.

A more detailed account of various exposures (especially those illustrated) will now be given; the localities described have been visited at various times during the last two years.

1. At Ella (Uva) are interesting exposures (Fig. I, Pl. XX, p. 366) in the bed of the Kitul Ela, just below the point at which it is joined by the small stream from near the Rest House. The main part of the intrusive rock consists almost entirely of granular greyish-green diopside (1152);[1] in parts scapolite and a little granular sphene are also present, and more locally hornblende or mica. A section (1153) through the junction with granulite at the point X in the figure shows granulite (a rock composed of quartz and orthoclase with a little pale-green diopside) passing very rapidly but with no loss of continuity into a granular rock consisting of colourless diopside with scapolite and a few rounded grains of sphene. At one point in the exposure a large crystal of diopside projects from the pyroxenite into the granulite, merely an exaggeration of the usual interlocking of minerals at the junction. The inner portion of the pyroxenite (at *h*) becomes rich in carbonates, and the relation to the rather impure granulites at *g*[1]

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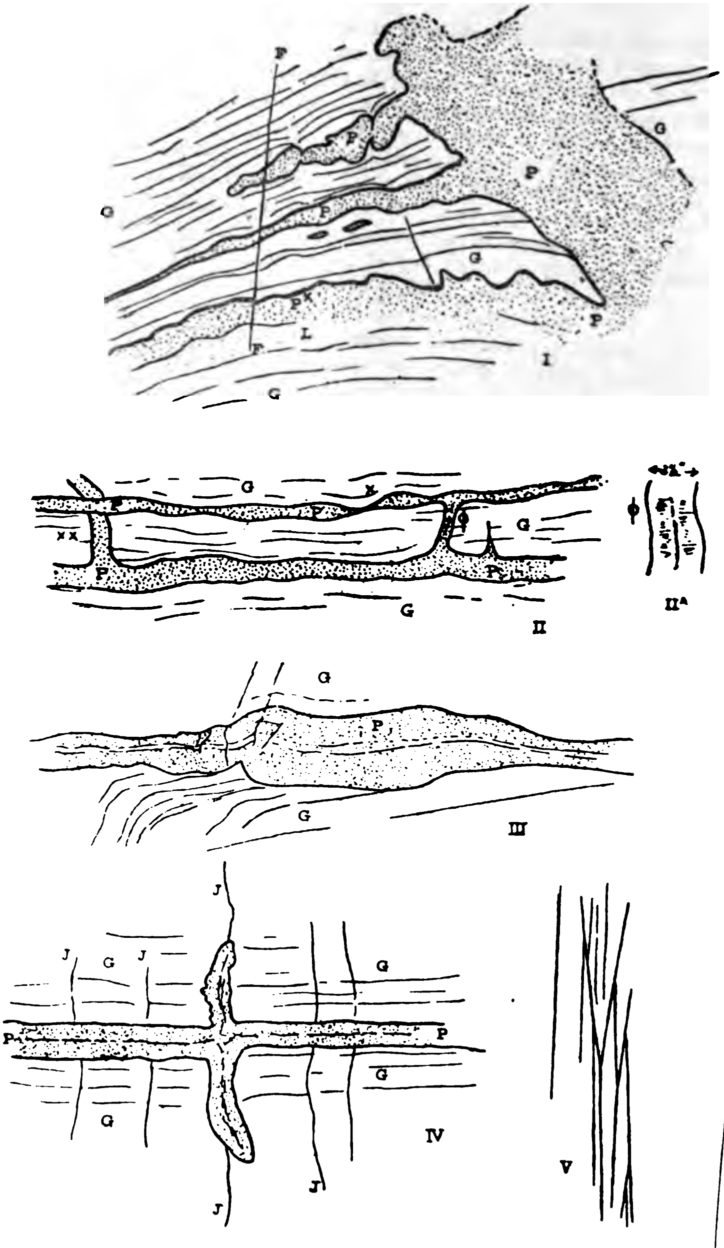
[1] The numbers in brackets refer to thin sections in the author's collection.

is not quite clear. The bands of intrusive pyroxenite following the granulite foliation planes tend to pass into lenticles, as if by a process of pinching, the lenticular forms being exactly followed by the granulite foliation planes; this fact, and the junction phenomena, makes it seem likely that the granulites were not in a completely consolidated state when the pyroxenic material was introduced. Similar 'pinching' is shown in Fig. II, Pl. XX, p. 366, at X.

2. In the bed of the Talatu Oya at Uduwela, near Kandy, there are several exposures of pyroxenic rock. Fig. II shows sills of pyroxenite (nearly pinched out at X) combined with dykes along joint planes. A section (1067) of the junction at X shows the intrusive rock to consist internally of an aggregate of colourless diopside with a peripheral hornblendic zone passing into the granulite, in which plagioclase and diopside are the dominant minerals, and pyrite is also common. A section (1069) of the pyroxene further from the edge shows only colourless diopside with a trace of plagioclase and green spinel. A junction section (1068) at ϕ (Fig. II) showed orthoclase diopside rock (granulite) passing into a diopside plagioclase rock (pyroxenite) with accessory pyrite, sphene, and apatite. The (subordinate) plagioclase has an ophitic habit, enclosing more than one individual of diopside, which is also intergrown with it in radiating root-like fashion. In the central part of the dyke mica becomes abundant, and is arranged in planes perpendicular to the edges of the dyke, as indicated in Fig. IIA, Pl. XX, p. 366. One other slide (1066) from the place marked XX shows an aggregate of diopside and amphibole with a little accessory pyrite.

Some smaller dykes at Uduwela are very micaceous; a section (1149) of one about an inch wide shows granulite (quartz-orthoclase-plagioclase rock with a little diopside) passing successively into diopside rock with a little plagioclase, diopside rock, and diopside-mica rock. The mica is in hand-specimens the most conspicuous mineral, and is arranged in planes perpendicular to the edges of the dykes.

3. Fig. III shows a zoned pyroxenite dyke cutting the foliation of the Charnockite Series, exposed in the bed of a stream entering the Badulla Oya from its right bank, about 8½ miles from Badulla and near Nanla. The outermost zone (about 3 inches wide) shows under the microscope (1147) a compact intergrowth of colourless diopside (partly also in granular forms) with subordinate plagioclase. The diopside intergrown with plagioclase exhibits root-like forms, and the intergrowth is on a very fine scale, so that the plagioclase is not easily recognizable. The central one or two inches of the dyke are clearly marked by the presence of dark hornblende, which in the hand-specimen can be seen moulded on idiomorphic grey-green diopside in ophitic wire. In the thin section (1148) the hornblende appears pale bluish green, with pleochroism a pale straw, b bluish-green with a brown tinge, and c bluish-green. This is the usual amphibole characteristics of the rocks now described.



Intrusive Pyroxenites in the Ceylon Granulites.
In illustration of Mr. Coomáraswámy's paper.

4. There are good exposures of pyroxenites at Kadawat Oya bridge, between Belihul Oya and Halpe (near the 99½ mile-post), Sabaragamuwa. A number of pyroxenic sills and dykes occur, and very heavy hornblendic and pyritic types are characteristic. The dykes vary from mere threads up to 1½ yards in width. Some show very clearly penetration of the pyroxenic material along joints (Fig. IV). Several dykes have quite narrow central zones, consisting mainly of pyrite; in one case large individuals of pyrite occurred at intervals along this line. Some of the larger dykes have central portions composed largely of carbonates with abundant accessory minerals (amphibole, phlogopite, spinel).

A section (1122) from the point marked X in Fig. IV shows a rock consisting almost entirely of pale sea-green diopside with a very little pyrite, apatite, and phlogopite; the diopside has a very curious structure, the cavities being occupied by semi-ophitic plagioclase. The whole dyke is about 6″ wide. A section (1123) of another dyke, 6″–8″ wide, proves it to consist mainly of very pale sea-green diopside, with some strongly pleochroic phlogopite, yellowish-green amphibole, green spinel, pyrite, apatite, and calcite. The diopside tends to granular forms, moulded by the mica and spinel, the latter being apparently almost the last formed mineral, occupying interstices amongst the grains of pyroxene. As the junction with granulite is approached the mica dies out, and some felspar and pink garnet come in. One other dyke, very dark in colour, consisted mainly of hornblende (especially in the central zone), pale bluish green in thin section (1150), and diopside with a trace of plagioclase occupying interstices; the hornblende has a strong tendency to crystalline form, even when in contact with diopside (a reverse relation is found in the central zone of the dyke shown in Fig. III, Pl. XX, p. 366, see description above).

5. 'Thread dykes' and others slightly wider. These very narrow dykes appear as dark lines crossing foliation on the surface of rock exposures (Fig. V). Under the microscope there appears nothing more than a rapid concentration of hornblende along a zone perhaps ⅛ inch wide (1103). These very narrow dykes are often in more or less parallel groups of two or three (Fig. V); sometimes they intersect at acute angles. Occasionally they widen out into dykes an inch or more wide, clearly visible in the field, but with such indefinite margins as to be hardly recognizable in hand-specimens.

A few additional examples may be briefly referred to.

6. A sill of grey-green pyroxenic rock 6–8 feet thick is exposed in the river bed below the road, about 10⅛ miles from Badulla on the Bandarawela road. The rock (1109) is a coarse aggregate of diopside and scapolite with scattered idiomorphic sphenes; other varieties consist practically entirely of diopside, individuals of which reach ¾ inch in width. The rock is very tough. Somewhat similar rocks are found, not quite *in sitú*, on the slope below the 69th mile-post on the Badulla Nuwara Eliya road, and some of these are very handsome coarse aggregates of diopside, amphibole, and scapolite, with calcite and idiomorphic sphene (often over ⅛ inch

long). The magnesian silicates and scapolite are idiomorphic towards the calcite and present a handsome appearance in weathered specimens.

In the Uma Oya below there are numerous exposures, both of 'thread dykes' and of intrusive pyroxenic and micaceous rocks, as well as of coarse felspathic pegmatites, with which their relations are somewhat confused.

7. Of pure mica rocks or veins there may be instanced those described in the (first) "Administration Report of the Mineralogical Survey," Colombo, 1904. Analyses of mica will be found in Professor W. R. Dunstan's "Reports on the Results of the Mineral Survey [of Ceylon] in 1903-4," London, 1905.

One example of a mica rock or vein may be quoted from the (second) "Administration Report of the Mineralogical Survey," Colombo, 1905, p. 20. A large vein of brown phlogopite is exposed in the Mineran Oya, just within the boundary of Sherwood estate (about nine miles north of Balangoda), in the south-west corner. The vein is about 5 feet wide, and strikes 20° N. of E. and hades 70° S.S.E., and crosses the foliation of the granulites, which are inclined at low angles. The Oya has for some distance cut its way along the mica vein, which is exposed in the bed of the stream. The largest crystals are 18 inches in diameter, but somewhat flawed.

8. A fairly typical zoned mica pyroxene dyke, from 2 inches to 1 foot wide, is found cutting the zircon granite (Balangoda group) of Massena estate, Balangoda. As the zircon granites are themselves intrusive in the granulites,[1] the pyroxenic intrusions would thus appear to be removed from the date of intrusion of the material composing the Charnockite Series, by the period required for the intrusion of the Balangoda group.

Canadian analogies. The rocks described closely resemble the pyroxenic rocks associated with the apatite deposits of Canada, described by A. Osann ("Notes on certain Archean Rocks of the Ottawa Valley," Geol. Surv. Canada, part O, Ann. Rep., vol. xii, 1902), and by C. H. Gordon ("Pyroxenites of the Grenville Series in Ottawa County, Canada," Journal of Geology, vol. xii, No. 4, 1903, pp. 316–325), who states that the evidence there too "clearly warrants the conclusion that the pyroxenic rock is intrusive." Detailed descriptions and further references will be found in the papers mentioned.

Summary. A group of pyroxenites, in which the minerals diopside, phlogopite, hornblende, and scapolite predominate, while sphene, plagioclase, pyrite, apatite, and spinel are often accessory, occurs in small sills and dykes intrusive in the Charnockite Series or granulites, and in one case apparently also in a zircon granite of the Balangoda group. The pyroxenic intrusions have usually a zoned or laterally symmetrical structure analogous to that of mineral veins. The intrusive material never shows a chilled edge, but there is a rapid transition from the pyroxenite to the granulite. The course of the small sills and dykes of intrusive pyroxenic material is usually determined by the foliation planes and joints of the granulites or Charnockite Series.

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[1] A. K. Coomáraswámy, "The Balangoda Group": GEOL. MAG., 1904, pp. 418–422.

EXPLANATION OF PAGE-ILLUSTRATION, PLATE XX (p. 366).

INTRUSIVE PYROXENITES IN THE CEYLON GRANULITES.

FIG. 1.—Intrusive pyroxenite at Ella (Uva); area shown about 6 × 4 yards. P, pyroxenite; G, granulite; F, fault.

,, 2.—Pyroxenite sills and dykes, Uduwela (Central Prov.); length shown about 8 yards. P, pyroxenite; G, granulite.

,, 3.—Pyroxenite dyke with well-marked symmetrical structure, exposed in feeder of Badulla Oya, near Naula; average thickness, 6 inches. P, pyroxenite; G, granulite.

,, 4.—Intrusive pyroxenite following foliation planes and joints in granulites (also in Figs. 1 and 2), Kadawat Oya bridge (Sab.); thickness, 6 inches. P, pyroxenite; G, granulite; J J, joints.

,, 5.—'Thread dykes,' exposed in feeder of Badulla Oya, near Naula; average thickness, ½ inch.

KANDY, *June* 19, 1905.

VI.—GOLD AT KNYSNA AND PRINCE ALBERT, CAPE COLONY.

By ERNEST H. L. SCHWARZ, A.R.C.S., F.G.S.,
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IN 1895 the author visited the Prince Albert Goldfields, and later the Millwood Goldfields in Knysna, and has had the subject constantly before him till quite recently, when, in reviewing the whole question in connection with the geology of the region, which he has now worked out under the auspices of the Geological Commission of the Colony of the Cape of Good Hope, he was able to come to some definite conclusions. The gradual building up of convictions on a subject like this, as facts became clearer with increased knowledge derived from the reports of prospectors, the progress of the Survey, and the access to literature bearing on kindred questions, led to the acceptance of certain general principles, which the author has thought worth while to state in definite form for criticism. The peculiar points in the occurrence of the precious metal in these localities cause them to rank high as fields for research, if not for general enrichment of the inhabitants of the Cape Colony.

The Millwood fields lie in the Outeniqua Mountains, shut off on the north by high grass-covered ridges with many picturesque peaks, rising to heights of about 4,000 feet, on the south by lower hills covered with dense forest. The Outeniqua Mountains form the first of a series of parallel chains that screen the Karroo from the coast, and on the seaward side there is but a narrow coastal ledge separating the foot-hills from the shore of the Southern or Indian Ocean. The rainfall is abundant, but subjected to periods of drought lasting from three to four months; on the whole, however, one can say that there is a heavy shower once a week. The ground about the goldfields is all on a steep slope, and storm-water rushes off with great vehemence, but the covering of grass which the hills possess retains a certain amount, which is in part returned to the surface by springs.

The Prince Albert Goldfields, on the other hand, lie out in the very heart of the dry country, where droughts last eighteen months and more; where the rain comes with thunder-clouds, perhaps a dozen times in good years during a twelvemonth, and then lasts but an hour or so. The country is kopje veldt, that is, cut into innumerable little hillocks of bare rock on which the scanty Karroo bushes thrive. The roots of these woody plants penetrate into the cracks in the shales and sandstones, and carry down soil with them in the crevices, but there is no covering of soil on the surface. The streams are very steep-graded, and even along the large rivers there are very scanty patches of alluvial soil. Denudation is mostly affected by changes of temperature, which reduces the rocks to small fragments; these are then further reduced by wind, which rolls them about, and finally carries them away in small particles. The rains are so tremendous, when they do fall, that the ground is covered with a continuous sheet of water, hill and valley alike, but only for a few minutes; before the sun can come out again this mass of water is tearing down the runnels into the main channels, and roaring its way to the sea.

The Millwood Area.

The coast range of mountains west of this place can be stated generally to consist of an S-shaped fold of Table Mountain Sandstone, the anticline occupying the north side and the syncline the south. The northern limb of the anticline dips under Bokkeveld Slate, containing fossils of an American type, belonging to the Lower Devonian; the syncline rests on pre-Cape rocks, Malmesbury Beds injected with granite, probably of very ancient age. This fold is reduplicated in several places, and subsidiary folds become added to the main syncline and anticline. At Mussel Bay and George there is an immense boss of granite, against which the folds are huddled on the north side, so that syncline and anticline are pressed together, and all the strata dip south. The granite is somewhat different from the main mass which exists in the south-west of the Colony, as it is a white mica granite; towards the eastern end of the boss the rock has been sheared, and later injections of tourmaline granite have filled in the spaces produced by the movement. At the end of the granite there is a tract of slates, and then another great mass of granite. The two bosses are connected by a dyke which traverses the slates, which at one point suddenly changes its strike from N.E. to E.N.E. The substance of the eastern granite appears not to have been sheared like the end of the other boss, and I am inclined to believe that this is not a true boss, anchored to the basement granite of the south-western districts, but is an immense lateral offshoot injected horizontally into the slates. The crush which buckled up the mountains, coming from the north, was brought up against the main granite mass, but where this ended the thrust sheared the termination and deflected the great arm of granite seawards.

Where the granite ends the whole nature of the rocks of the mountains changes; no longer have we miles of strata on end, as near George, but the folds widen out, and dips of 10° to 15° prevail. West of this point the dips are south all through the mountain ranges; east of this point there are both north and south dips; in other words, the folds are upright and open, instead of being pressed together, and inclined to the south.

The direction of the granite dykes is near here N.E., and then suddenly swings round to E.N.E., so in the strike of the Table Mountain Sandstone there is a sudden change from east and west to E.S.E. Any small scale map of South Africa will show distinctly the streaming of the mountains round a point near George, and the recent survey of that part by the author showed that the cause of this change in the direction of the mountain chains was the termination of the granite. It is not till we get beyond the colony borders into Natal that we find granite again along the southern part.

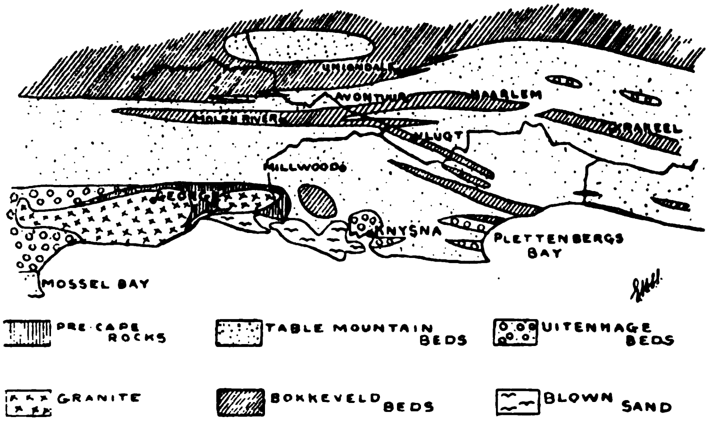

FIG. 1.—Map of the Coastal Plateau in George and Knysna, showing the bending of the strike round the end of the granite.

It is in the angle of the bend in the Table Mountain Sandstone that the fissures occur which are now filled in with auriferous quartz. In between Millwood and the granite there is a syncline filled in with Bokkeveld Slates, and the quartz-reefs traverse the slate formation equally with the sandstone formation; but there are certain differences. In the slate the quartz-reefs are massive bodies of white veinstone, with a certain amount of pyrites and copper pyrites included in it; none of the reefs have yet been opened up properly, but they appear to be continuous over large areas and are constant with depth. They do not branch or break away from their general lie, which is parallel to the strike of the rocks, but with a dip somewhat greater. In the sandstone the veins are much less constant, tending to pinch out and run into stringers, while the veinstone is often cased in a layer of silvery grey-green phyllite, which I take to be material that has been carried mechanically into the fissure before the quartz began to form from solution. The lie of the veins here also is along the strike of the rocks, and the dip generally is greater than the dip of the beds, but there is a good deal of variation in regard to the latter point.

The difference between the two modes of occurrence can be traced to the varying tensile strengths of the sandstones which go to form the Table Mountain Series; all grades of grain from gravel to the finest meal-sand occur in the beds, and in addition the coherence of the particles, due to cementing substances such as iron sulphides and silica, must be very different in the successive layers. In the Bokkeveld Beds, however, there is far more homogeneity in the texture of the beds, although when subjected to surface weathering there appears to be a good deal of variety; in the bulk, however, we can take the Bokkeveld Series to be made up of a continuous deposit of clay-slates, with occasionally a sandy or calcareous bed. North of the mountains great banks of quartzite appear, but to the south these have not been noticed, and it has been supposed that the beds along the coast represent sediments which have been laid down in deeper water than those to the north of the mountains.

The ore-deposits in the quartz-veins in the Table Mountain Sandstone area consist of gold, pyrites, galena, blende, and sometimes carbonate of iron. In the Bokkeveld area there are copper and iron pyrites. All these ores I take to have been deposited in the quartz-veins by lateral secretion, and not by the ascension of mineral solutions from great depths. By lateral secretion I do not mean to imply that the immediate walls of the veins have supplied the material, as argued by Sandberger, but that the rocks within a reasonable distance of the veins have done so, according to the broader views enunciated by Le Conte. At the same time I believe that there is an ascension of metallic substances in solution from the depths, only that here this explanation of the mineralization of the veins is out of the question, because the pre-Cape rocks underlying the Table Mountain Sandstone and in the immediate neighbourhood show no signs of quartz-veins bearing deposits of ore.

The vertical extent of the reefs is a question of great moment to the mining engineer, as upon the continuance of the reef depends the successful employment of capital. If the fissures are caused by an immense arm of granite, and not by a boss, then they will not go down into the earth to indefinite depths. We have reefs cropping out at 2,600 feet above sea-level in the Table Mountain Sandstone, and in the Bokkeveld Beds they are found at only a couple of hundred feet above sea-level. I consider it a low estimate if we take it that at least half of the distance of the mountains from sea-level upwards has been denuded away, and that the reefs originally extended to 5,000 feet above the present ocean surface. The reefs go at least 1,000 feet below the sea-level, for on the sides of the Little Homtini River we have a section showing a reef commencing at 700 feet, and traversing the side of the ravine down to 200 feet, with every appearance of its continuing indefinitely.

I have shown reason to believe that the reefs represent fissures due to a tearing in the rocks as they bent round the end of the granite; they must, therefore, follow roughly a succession of shells of tension round the end of the granite arm, the actual course of the fissures being directed by the lie of the rocks, which would be stronger in one direction than in another, but the vertical extent, I think, would be independent of the formations, and the fissures traverse any kind of rock strata that may exist in the area of the shells of tension.

The Table Mountain Sandstone represents a shore deposit, and the Bokkeveld Slates a deeper-water formation. Taking into consideration the extent and distribution of these sediments, it is fairly well proved that they must be derived from a continent which formerly existed to the north of where they now lie. This continent we can see emerging from a later covering of Karroo rocks in Namaqualand, Prieska, and the Transvaal, and it contains deposits of minerals of exactly the kind which we find in Knysna, the O'Kiefs copper deposits and the Rand gold-banket, to take two instances. The detritus from this land would naturally carry with it a certain amount of the mineral ores, and they would be deposited along with the bulk of the sediments. There would be a rough sorting according to gravity, the heavier metals, such as gold, lead, and zinc, would tend to come to rest nearer the shore than the lighter ones, such as iron and copper, and I look to this action to explain the presence of the former group in the Table Mountain Sandstone and the latter in the Bokkeveld Slates.

In regard to the gold and associated metals, it is a well-known fact that sand does not tend to precipitate them, whether carried mechanically or in chemical solution, until the deposit becomes gravelly; and in the present case, although it is likely that traces of gold might be found in the sandstones on careful analysis, the major portion seems to have come to rest in a consolidated gravel or banket which occurs near the top of the series in this neighbourhood. Assays give 2 dwt. per ton of gold, and from its extreme hardness there is no possibility of mining this rock unless richer spots can be found. The banket dips under the Bokkeveld Slates, and comes up on the south sides of the inlier, so that it can be safely said to recur as a continuous sheet, dipping some two or three thousand feet below sea-level. In the Bokkeveld Slates pyritous layers occur, but as a general rule I think the ores of iron and copper were distributed fairly evenly throughout the mud that is now represented by the clay-slates: it partly impregnated them in the form of minute crystals and films, and in part has crystallized out in the form of cubes.

Having now traced the minerals from their original resting-place in the older rocks of the northern continent to the stratified deposits in Knysna, we have to follow the process by which they became leached out and redeposited in the quartz-veins. The circulation of water through the substance of rocks is sufficiently recognised, and I think I need not labour the point that, if there are strata in compression and a series of opening cracks within reasonable distance, the water will pass from the one to the other.

With regard to the power of water to dissolve metallic substances, Doelter[1] found that pyrites, galena, antimonite, spherulite, arsenical pyrites, copper pyrites, and bournonite were to a certain extent soluble in pure water when heated for four weeks in glass tubes to a temperature of 80° C.,[1] and that pyrites, galena, zincblende, arsenical and copper pyrites, and bournonite were soluble in water containing sodium sulphide under the same conditions.[2] There is, therefore, no reason to suppose that enormous pressure or heat were necessary to make these minerals go into solution, and that they must have consequently come up from great depths; with the exception of blende the minerals are soluble in pure water, given moderate pressures and temperatures, such as would exist a few thousand feet below the surface, for it must be remembered that in dealing with these matters, where temperature and pressure are high in the laboratory experiments, the same results can be attained in nature by very much less temperatures and pressures, owing to the vast lengths of time in which the process has to act. In the case of zincblende an alkaline sulphide was found necessary to cause it to go into solution, and whether the particular sulphide, or, indeed, salt of whatever kind, was really present in nature, or some other, the main point proved in Doelter's experiment was that the zincblende could be made to go into solution.

With gold we have a much more refractory element, but a trace of free chlorine in the water would be sufficient to dissolve the gold from the banket. The surface-water of Millwood is tinged brown with organic acids derived from the roots of the grasses and sedge-like plants that cover the slopes of the hills; hydrochloric acid is present in minute quantities, and may be accompanied with free chlorine, so that the possibility of this solvent being present in the underground water is not entirely ruled out. Other solvents are sodium and potassium chloride,[3] sodium silicate,[4] sodium sulphide, sodium sulphydrate, and sodium carbonate saturated with sulphydric acid.[5] Le Conte and Wurtz have shown that ferric sulphate is also a solvent, and Atkin[6] has pointed out that this is by far the most likely of natural salts that cause the solution of gold.

Posepuy has argued that water circulating within a few hundred feet of the surface, and derived by absorption from the atmospheric water, would be an agent which oxidized the salts which it carried in solution, and therefore, if we accept his theory, the sulphides which colour the sandstones blue, would first yield a sulphate, and the necessary solvent for the gold would be produced. But against this we have two undoubted facts in the area we are describing: the sandstones remain blue and have not the sulphides removed, even though we have very palpable evidence that Posepuy's vadose water is circulating through them; and, secondly, the Malmesbury or pre-Cape rocks in the neighbourhood, through which the deep-seated water would have had to pass to get to the mineral veins in the Table Mountain Sandstone, show no signs of having clefts or fissures which are filled in with ore and veinstone. The mineralizing water seems, therefore, to be undoubtedly that derived from the surface, and at the same time is not an oxidizing medium; if we are searching for a solvent, I think we should look to the ferric sulphide and not the sulphate as probably the active principle. The formation of ironstone gravel beneath the soil in so many places in the neighbourhood shows that the surface water does contain a very appreciable quantity of iron in solution.

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[1] Tschermak's Mitth., 1889, vol. xi, p. 319.

[2] l.c., p. 323.

[3] Egleston: Trans. Amer. Inst. Min. Eng., 1880, vol. viii, p. 455.

[4] Liversidge: Proc. Roy. Soc. N.S. Wales, 1893, vol. xxvii, p. 303.

[5] Becker: Mon. U.S. Geol. Surv., 1888, vol. xiii, p. 433.

[6] Atkin: Q.J.G.S., 1904, vol. lx, p. 390.

Doelter has shown that the sulphide is soluble to a certain extent in pure water, and sodium sulphide is a solvent for gold; there are no sources which I can see whence a sodium salt could be derived, but it seems reasonable to suppose that the ferric salt might take its place. Until experiments have been carried out in this direction, it is naturally impossible to make the assertion that any one salt, if present in the water, would have dissolved the gold, but an enquiry like this may be useful to show chemists in what direction geologists want their help. I think, however, I have shown sufficiently clearly that gold will go into solution in water containing salts which naturally occur in the rocks, and that it is not necessary for the salt to be a compound of oxygen.

Whatever may have been the solvent, temperature and pressure would increase its action. Certain salts like sodium sulphate are more readily soluble with increasing temperatures and pressure up to a certain point, when there is a sudden decrease, while if there is a contraction in volume when the salt goes into solution, pressure and heat decrease the solubility.[1] These cases, however, are rare exceptions to the general rule that the rate of increase of solubility is a function of temperature and pressure, and it is a fairly safe statement that in the case of gold the rate of solubility is far greater 10,000 feet below the surface than it is at 1,000 feet. On this fact depends the question whether the reefs become richer with depth, and unless the gold behaves exceptionally with its solvent we may say that they do. The banket naturally, being a stratified deposit, would be unaltered with depth, but serving as a source of gold for the quartz-veins, and being near the cracks down to great depths, it is almost certain that there is increased solubility and consequent deposition of gold.

I therefore define the Millwood gold-reefs as true fissure veins, limited, however, in depth by the extent of the disturbance caused by the arm of granite, and filled in with veinstone and ore by lateral secretion; the process of leaching out the gold in the banks and depositing it in the reefs I term the second stage. The third stage is the displacement, mechanically or chemically, of the gold in the reefs and the building up or the deposition of gold nuggets in the alluvial gravels.

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[1] Ostwald: Algemeine Chemie, pp. 1046, 1048.

In this stage must also be included the surface enrichment of the reefs, caused by the concentration of the precious ores from portions of the reefs that have been removed by denudation. The quartz, being more homogeneous than the sandstones which it traverses, stands out somewhat from the surface when exposed to the influences of denudation, but it soon crumbles up, and the particles get washed down with the rest of the detritus; the gold, however, tends to stay where it is, owing to its great density. When the water which has slowly percolated through the rocks, and has taken up certain quantities of ferric sulphate, gets to the quartz-vein, it slowly dissolves the gold in it, and then becomes lodged in the vein, splintered by surface-weathering agencies. So, either by mechanical means or by chemical means, the surface of a quartz-reef tends to become far richer than it is in the bulk. Pieces of enriched surface-reef have been found so studded with gold that the poor prospectors thought that at last they had got the parent reef of all the alluvial, but no body of reef has been found carrying gold in appreciable nuggets.

The process that I have outlined to explain the surface enrichment of reefs is the same for the formation of gold nuggets. These are found in the alluvial gravels of the creeks, but especially in mud in the crevices in the sandstone and under great boulders, and are found in considerable quantity. There is no law enforcing registration of gold finds, and many thousands of pounds' worth of nuggets have been passed into the bank without notification, but, for all that, from the proclamation of the fields in 1887 to March, 1905, a total of 3,370 ounces has been registered. I was led to bring in the explanation that the nuggets must have in great part been built up from solution, and are not merely particles that have been washed out of the reefs by the following considerations:—

1. With the exception of a very few instances, no reefs have been found containing gold in nugget form.

2. The nuggets, running up to three and four ounces, are found in places where it would be difficult to explain their presence, that is to say, in narrow crevices and hollows surrounded with light sand. One would have to explain how these large nuggets got pushed past obstacles if we are to consider them as having been mechanically brought into place.

3. Many of the nuggets, although occurring in the stream-bed, show quite sharp ridges and points, so that they cannot have travelled very far, yet there is no source near at hand whence they could have been derived.

4. The creeks and gullies contain gravelly patches which are washed out and all the gold recovered; a few seasons later the same hollows are worked and the gravels are found to be as rich as before,

yet the whole of the creek sides have been closely and systematically searched in vain for reefs containing nugget gold. Unless the nuggets have grown in the place they are found in by deposition from solution, where can they have come from?

5. The solution theory accounts for all known facts. The solvent salt ferric sulphate as well as perhaps a little chlorine is present in the surface water; the gold would therefore be dissolved, and according as it was redeposited slowly by evaporation or instantaneously by reduction of the ferric to the ferrous sulphate, the nugget would be built up with sharp edges or in a rounded form.

Gold is found in fairly average quantity in gravel on an old river level called the Poverty Flats, and also in the mud of the estuary of both the large rivers that drain the Millwood area, the Gowkamma (Homtini) and the Knysna. In both these cases I think it easier to explain the carriage of the precious metal by the solution theory rather than on the gravitation theory, for gold being so heavy tends to remain where it is in the quartz-reefs, and when found in the river-beds it sticks in the hollows and joints of the rocks.

The Prince Albert Goldfields.

The first gold nugget was picked up in the Prince Albert Goldfields in 1871, and twenty years afterwards the fields were proclaimed; they were de-proclaimed in 1898, but since then a good deal of prospecting has been carried on.[1] So far the gold has been only found on the surface; there are innumerable quartz-veins about here, from an inch or so in width to a foot and more, formed of interlocking combs of quartz crystals; the gold is often found in them on the surface, but directly they are sunk upon all traces of gold disappear. The gravels are fairly rich in some places, especially under ledges of sandstone which get loosened on the surface, and some of the nuggets are so fresh that they often exhibit minute octahedra of gold adhering to them with the faces quite bright and unscratched. There are many big saurian bones in the locality which lie about the surface as they weather out of the softer shales, and some of these have also been found to contain crystals of gold in their hollow parts. Mr. H. M. Oakley, who was at one time Inspector of Mines on the fields, informs me that those who used copper pans for washing for the gold very frequently found them coated with mercury after a short while.

So much prospecting had been done on these fields that I was compelled to reluctantly state that the gold must be alluvial, and had been brought from a distance. From a geological point of view this was what I should have expected, as the Karroo shales are too unaltered and too young a formation altogether to carry highly mineralized veins, and the veinstone, also, is so totally different from the usual gold-bearing quartz that no miner would sink on the specimens obtained from the reefs.

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[1] An interesting description of these fields, with an account of the general geology, was published by Mr. Sawyer as a Parliamentary Report, G. 45, 1893; the whole question was again discussed by the author, Trans. Phil. Soc. S.A., 1904, xv, pt. 2.

How, then, did the gold get to the locality? The goldfields lie almost midway between the folded mountain range, the Zwartebergen, on the south, and the dolerite-capped escarpment of the great inner plateau on the north. The country is hilly, and the tops of the hills reach a pretty level skyline of about 3,500 feet; on the immediate south there is a wide plain separating it from the mountains. The gold is found equally on the tops of the hills as in the gullies, and there is no higher ground from which it could have been washed anywhere within twenty or thirty miles.

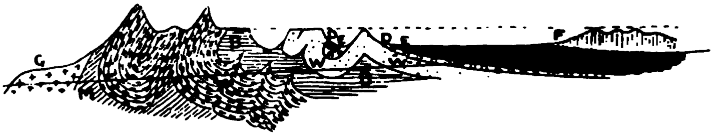

FIG. 2.—Generalized section from the Zwartebergen to the Prince Albert Goldfields, showing the Old High Level Plateau, which has now nearly disappeared.

G, granite; M, Malmesbury Beds; T, Table Mountain Sandstone; B, Bokkeveld Beds; W, Witteberg Beds; D, Dwyka Beds; E, Ecca Beds; F, Beaufort Beds.

A careful piecing together of evidence has shown me, however, that the great river-cut plain that can be seen so plainly in Uniondale and Willowmore must have extended all over this country as well; it was on a level of from 3,500 to 4,000 feet, and stretched northwards from the Zwartebergen to probably the foot of the inland plateau escarpment. Narrow gravel-covered ledges can still be seen on the foot-hills north of the Zwartebergen, and a very much folded range in front of the main chain, composed of hard quartzites of the Witteberg Series, has been cut to a level about 4,000 feet. Far to the north, the hills about the goldfields can be seen cutting a level skyline, and I have been led to consider that there is satisfactory evidence for the former existence of this great high-level plateau, although the traces of it to-day are so scanty. Everywhere where the remnants of the plateau exist, in the foot-hills of the mountains, on the tops of the skirting range, and on the tops of the hills about the goldfields, gold has been discovered. The rivers in those days flowed over this plain northwards, carrying the gold in their waters, whether chemically or mechanically; since then, however, the channels have been diverted, and an easterly-flowing stream has excavated an immense plain at a level of some 1,000 feet below that of the old one, separating the hills about the goldfields from the mountains.

The Zwartebergen are made up of Table Mountain Sandstone, immense quantities of which have been removed in past ages, and a very little gold that may once have existed in the rock became concentrated in the gravels laid down on the old high-level plateau; I conclude, therefore, that the little outlier of the old plateau existing in the Prince Albert Goldfields has derived its gold from the Zwartebergen. I could find no banket beds immediately to the south of the goldfields, but not very far to the east I found a well-marked bed, which I photographed and reproduced in the paper just referred to.

I was therefore justified in pronouncing against the likelihood of finding quartz-reefs in this neighbourhood, on the grounds that the experience of prospectors was against it, and that from general mineralogical and geological considerations it was impossible to get gold-bearing reefs there.

How, then, can it be explained that the quartz-reefs do contain gold on the surface, sometimes in such quantities that the volume of the gold is far greater than that of the quartz, and the gold nuggets are so fresh, some of them, that crystalline forms are present? It is impossible that the latter can have been rolled any distance.

The theory of solution by ferric sulphate, I think, explains all the facts here as well as in Knysna. The Karroo shales and sandstones contain a considerable quantity of iron pyrites in the form of crystals and thin films colouring the rocks, and it is easy to see how a sulphate could be derived from this salt; where there is lime on the surface the elaboration of a sulphate is very apparent, for the lime becomes gypsum, leaving the iron in the form of red or yellow ochre. Given, then, ferric sulphate and alluvial gold, it is easy to follow the process of the building up of the gold octahedra and nuggets generally.

When it rains most of the water instantly flows away; a little remains and soaks in, absorbing the ferric sulphate and afterwards dissolving a certain amount of gold. This then gets drawn into crevices beneath the sandstones, lodges in hollows in the quartz-reefs where the crystals do not occupy the whole width of the fissure, in the cavernous portions of bones, and finally in the sand on the bottom of the creeks. Here it has ample leisure to corporate during the prolonged droughts, and the crystalline gold is the result. I look to the more frequent application of evaporation to explain the occurrence of gold crystals in the Karroo goldfields; in Knysna, where there is never a real drought, crystals have never been found. Some of the gold nuggets are powdered with red gold, which perhaps is the gold precipitated from solution by the reduction of the ferric salt to the ferrous one, the action being too quick to allow of the coherence of the particles. In the sand the gold has been precipitated in the form of minute spicules.

REVIEWS.

I.—The Museum Humfredianum, 1779. By C. Davies Sherborn.

All interested in Conchology will be glad to know that a copy of this work has at last been discovered in the Hancock Museum, Newcastle-on-Tyne, and the mystery as to whether or not it contained generic and specific names is now finally set at rest. The Catalogue of the Humphrey Museum is of no scientific value whatsoever. I am printing a full description of this rare tract in the *Annals and Magazine of Natural History*, and as the Editor of the GEOLOGICAL MAGAZINE has suggested that it would be worth while to print here a few entries as an illustration of the matter that interested the scientific, and awed the vulgar, in those days, I have therefore selected and subjoin a few of the items contained in this curious work.[1] The original Catalogue will eventually find a home in the British Museum (Natural History):—

A very curious specimen of the bark of a tree in coal slate, from Yorkshire.

An exceedingly fine and large Oriental long devil.

A very curious *lusus naturæ* in an English pebble, representing a hen with herbage, and another in a flint, representing a leg and a foot.

Two vice-admirals, and 16 more.

A petrefied nautilus freely exhibiting the concamerations and siphunculus, from Sheepy Island.

A pair of Tower of Babel, exceedingly fine.

A Persian music, and a fine yellow furbelowed oyster.

Part of a very scarce alatus and a curious buccinum, from Hordwell Cliff, and a piece of limestone with pediculi trilobi imbedded in it, Wales.

A large slab of a singular kind of stone, lately discovered in Derbyshire, supposed by some naturalists to be a species of lava.

Part of a large ammonites with ramified chambers, sprinkled with marcasites, from Bath.

A large Swiss breeches, from the East Indies.

A mass of bivalves imbedded in sandstone.

A large mass of bones, with fragments of limestone, in a red calcareous bed, from the rock of Gibraltar.

A crystallized lady and a portrait of Mother Shipton in flint.

Two suns, a staircase, and 6 more.

Two poached eggs, a toad, and 6 others.

Part of the outer twirl of a very large ammonites.

A pediculus in Fuller's earth, rare.

A pediculus marinus extended, and another rolled up, from Dudley.

One valve of a polyleptoginglimos, with curious adhesions of purple furbelowed oysters.

Two shoulders of mutton and two large leopard cowries.

Two lions in shell-work.

A black slate with impression of a lizard, very rare, from Davila's collection.

A skeleton of a fish (a kind of plaice) in an iron stone, from Westmoreland.

A fine Hampstead pebble; a beautiful jasp-achates, Germany; and a rare brown cauk, Derbyshire, all polished.

Two magpies, a devil, a painted cockle, a sun, 2 false Guinea admirals, and 2 Otaheite cowries.

An impression of a flying-fish in yellow slate, Solenhofen, very rare.

Two ass's ears, a devil, 2 figs, 2 blackamoor's lips, and 6 more.

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[1] The spelling is after the original work.

An exceedingly fine group of 13 club spines of echini in chalk, Kent, and a fine cast of a cuneous frosted with marcasites and spars, Bath.

An Oriental devil of the first magnitude, very fine.

The body of a species of encrinus, composed of angulated plates, *non descript.* and very rare, from a chalk pit in Surrey.[1]

A most capital petrefied subject, being the thigh-bone of some very large animal,[2] supposed to be either an elephant or hippopotamus, found in a stone quarry at Stonsfield, Oxfordshire.

The skeleton of an alligator, in black slate, extremely rare, Germany.

A most elegant and capital petrefaction of an *Echinus overius,* with about 50 of its spines adhering to it, placed in as nice order as in a recent shell, imbedded in chalk, Kent. This specimen may be truly said to be invaluable, and is undoubtedly unique.

Three small gregories.

II.—ON LISTS OF FOSSILS.—YORKSHIRE GEOLOGY. *THE NATURALIST.—ACTINOCAMAX PLENUS.*

Mr. Marr, in his presidential address to the Geological Society in February last, made the following excellent remarks:—"It is surprising how many fossil lists of the organisms contained in the strata of our own Island have been drawn up as the result of a few hours', or at most of a few days', work by the collector." And "The rough-and-ready methods which, in some cases, have been pursued in compiling lists of fossils of the different sediments would not be tolerated at the present day in any other branch of science; it is time, indeed, that the stratigraphical geologist should apply himself to his own branch of work with the assiduity and attention to detail which are now expected of the palæontologist in the Museum." These words should be written in letters of gold across the study-wall of every field geologist.

Yorkshire men, however, care for none of these strictures, for their diligence in the search for fossils is well known. That it was greatly stimulated by the visits of Dr. Rowe to the Yorkshire Chalk was obvious, and one of the chief results is seen in the July number of *The Naturalist,* where Mr. C. Thompson describes the first discovery of *Actinocamax plenus* in the 'Black Band' and overlying a few inches of marl in Yorkshire. Repeated and continuous search has at last been rewarded, for altogether three specimens are recorded, one of which was found by Dr. Walton. This characteristic zonal fossil is fairly common south of the Humber, but up to the present discovery not a single specimen has been found north of that river. As Belemnites are 'spotty' things, and from their shape roll about and get into depressions of the sea-floor, it is quite likely that it may be some time again before another lot is found.

The July number of *The Naturalist* is of considerable geological interest, for, besides the above note, there are papers by Kendall on the concealed coalfields of Yorkshire, Derbyshire, and Nottinghamshire; C. Johns, Geological Notes on Askrigge; Stather, on the Geology of Louth; and Brown, on *Janassa bituminosa* from the Marl Slate, Thickley. The number is excellently illustrated, and the journal well deserves the place it holds as a record of the Natural History of the North of England.

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[1] Very interesting in view of the recent 'discovery' of *Marsupites* in Surrey.

[2] Probably *Megalosaurus.*

REPORTS AND PROCEEDINGS.

GEOLOGICAL SOCIETY OF LONDON.

June 21st, 1905.—J. E. Marr, Sc.D., F.R.S., President, in the Chair. The following communications were read:—

1. "The Relations of the Eocene and Cretaceous Rocks in the Esna-Aswan Reach of the Nile Valley." By Hugh John Llewellyn Beadnell, F.G.S., of the Geological Survey of Egypt.

At the meeting of the International Geological Congress held in Paris in 1900, the author brought forward evidence from the Baharia Oasis and Abu Roash to show that there was a marked unconformity between these two systems in the northern part of the country. The Jebel-Awaina succession shows that in the southern part of the country, where the Upper Cretaceous and the Lower Eocene occur in their fullest development, there is no sharp line of demarcation between the Cretaceous and the Tertiary, and no disturbances in the stratigraphical succession. This is confirmed by the succession in the Kharga Oasis, where there is no trace of an unconformity. Dr. J. Ball's conclusions to the contrary were mainly based on the supposed irregular variation of the Esna Shales; but where this occurs it is mainly due to the fact that, with a slight increase of carbonate of lime, these beds became almost indistinguishable from the overlying marls and marly limestones of the Eocene. The author finds in Jebel Nur el Ghenneiem some 180 feet of green clays between the *Echinocorys* Chalk and the Eocene marls and limestones, and a perfectly conformable succession throughout. Near Ain Amur there is a considerable development of fossiliferous limestones at the summit of the Cretaceous rocks, and many of the fossils are hardly distinguishable from Eocene species. The author is of opinion that the Farafra succession falls into line with that which obtains in the southern part of the country. An important piece of confirmatory evidence is furnished by the discovery of a rich fauna in 'ashen-grey clays' in the Esna-Aswan Reach of the Nile Valley by Dr. W. F. Hume, in the clays above the *Pecten* Marls in the neighbourhood of Esna.

2. "A Contribution to the Study of the Glacial (Dwyka) Conglomerate in the Transvaal." By Edward T. Mellor, B.Sc., F.G.S. (Communicated by permission of the Director of the Geological Survey of the Transvaal.)

The survey of a district lying east of Pretoria and extending from near the Diamond Fields to Middelburg, has recently afforded much additional information with regard to the Glacial Conglomerate in this part of South Africa. The district lies on the northern edge of the principal area occupied by the Karroo System, and includes a number of outliers, the area between which affords information as to the source of the material of the Conglomerate and the character of the land-surface on which it was deposited. This surface is smoothed, grooved, and scratched by ice-action. The Karroo System is here only 400 or 500 feet thick, and the Conglomerate usually about 50 feet; but, where deposited in hollows, it may reach 200 feet or more in thickness. The fragments are usually from 1 to 3 feet in diameter, but may attain as much as 8 or 10 feet; they are often facetted and sometimes show striations. The majority of the boulders are of local origin. True bedding-planes are rare in the Conglomerate, but there are included patches of sandstone, mudstone, or shale, some of which show ripple- or eddy-markings. The striæ are remarkably constant in direction, and they and the transport of boulders indicate an ice-movement from the north-north-west to the south-south-east. In the Prieska district Rogers and Schwarz found the movement to have been from north-north-east to south-south-west, and the same direction is given by Schenck from near the junction of the Orange and Vaal Rivers. During 1904 outliers of the Conglomerate were found farther north, near the junction of the Elands and Olifants Rivers.

3. "On New Oolitic Strata in Oxfordshire." By Edwin A. Walford, F.G.S.

The divisions of the Inferior Oolite of North-West Oxfordshire are described, and a quarry on the border of the county cited where the Cotteswold facies dies out in the '*Parkinsoni*'-stage. A higher division of the same stage (the *Trigonia signata* beds) of Northamptonshire type is shown to sweep over the North-Eastern Cotteswold region. The siliceo-calcareous beds (Chipping Norton Limestone) cover the countryside which gives them their name, and are about 30 feet thick. Fossiliferous strata, separated from the Chipping Norton Limestone by a bed with vertical markings and a black clay-band, indicative of much 'inter-waste' of these and other beds, are described. They are shown to be similar to the Lincolnshire (Ponton) strata described by Morris, Judd, and Woodward. A new term is proposed for these beds, which are characterized by the presence of the shell *Neæra*, from the *Perna* Marls above the black clays to a higher series of black and green clays underlying the Stonesfield Slate. These beds and the Chipping Norton Limestones are classed with the sub-Bathonian. The beds equivalent to those of Oxfordshire have, in Lincolnshire and Northamptonshire, been known in part as Upper Estuarine. In the 20 feet of Oxfordshire strata there appears to be represented the 150 feet of the Lincolnshire Limestone and the Upper Estuarine of the north-eastern counties. The author expresses the hope that his work may help towards the discrimination of the two kinds of deposit known as Lincolnshire Limestones, inasmuch as the fossils characterizing each local (Oxfordshire) stratum have been collected from the beds *in situ*. Lists of fossils are given.

4. "The Causes of Variegation in Keuper Marl and in other Calcareous Rocks." By Gerald Tattersall Moody, D.Sc., F.C.S. (Communicated by Professor W. W. Watts, M.A., F.R.S., Sec.G.S.)

Analyses of a large number of specimens of Keuper Marl bring to light the fact that the red portion of a variegated rock contains a considerably higher percentage of iron and lower percentages of calcium-carbonate and magnesium-carbonate than the green portion. This is in agreement with earlier observations that red strata are usually less calcareous than adjacent green strata; but the author is unable to confirm the hypothesis advanced by Maw,[1] that the lighter-coloured bands in variegated rocks are produced by bleaching or discoloration of red rocks through addition from extraneous sources of lime and magnesia. On the contrary, it is found that the removal of iron existing as ferric oxide from a homogeneous rock-mass is inhibited if calcium-carbonate, or magnesium-carbonate, or both of these substances be present. When, however, a chalybeate water (ferrous bicarbonate solution) permeates a rock containing magnesium-carbonate or calcium-carbonate, iron is precipitated as ferrous carbonate, and an equivalent weight of magnesium or calcium passes into solution. Subsequent access of air oxidizes the ferrous carbonate, and red or yellow ferric oxide is produced. The author finds that when a green marl is subjected to the action of chalybeate water in the manner indicated, it is readily converted into a material closely approximating, both in appearance and in composition, to the natural red marl of the same rock-mass.

The author concludes that the variegation of the Keuper Marls and of other calcareous rocks has been brought about by the percolation of chalybeate water through the light-coloured mass, the more porous parts of which have in consequence become stained with ferric oxide, while the harder and more crystalline parts, being non-porous, have remained unchanged. The uniformity in distribution of ferric oxide in some red rocks, such as the New Red Sandstone, suggests that the iron contained in them has probably been derived from chalybeate water in a similar manner.

The next Meeting of the Society will be held on Wednesday, November 8th, 1905.

CORRESPONDENCE.

WHERE ARE THE TYPES?

Sir,—May I ask if any of your readers can kindly give me the information as to where may be found the types of S. P. Pratt (Kelloway Ammonites from Christian Malford) and of Young & Bird (Lias Fossils in "Geology of Yorkshire")? The information is required for the purposes of the *Palæontologia Universalis.*

Westfield, Thame, Oxon. S. S. Buckman.

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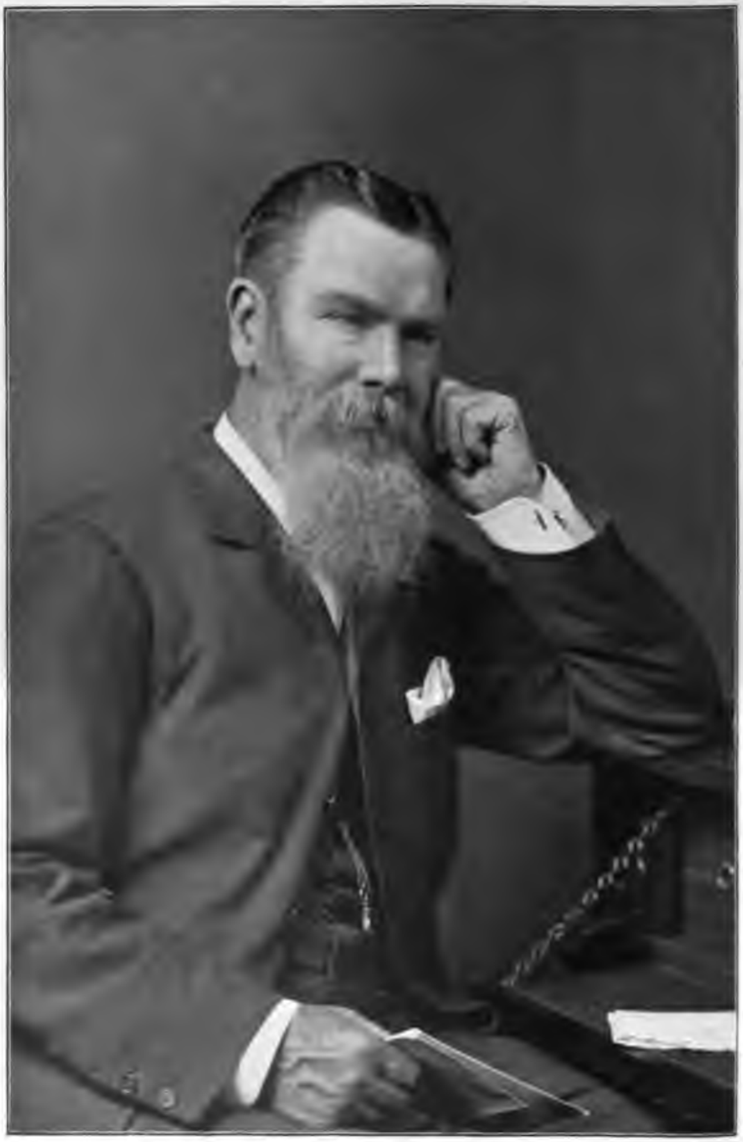
[1] Quart. Journ. Geol. Soc., vol. xxiv (1868), pp. 35 et seqq.



Yours very faithfully,
John W. Judd.

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THE

EOLOGICAL MAGAZINE.

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ORIGINAL ARTICLES.

I.—Eminent Living Geologists:

John Wesley Judd, C.B., LL.D., F.R.S., F.G.S.

(WITH A PORTRAIT, PLATE XXI.)

JOHN WESLEY JUDD was born at Portsmouth February 18th, 1840. His father belonged to a branch of an old Kentish mily that had been settled for several generations in the Isle of ight. His mother was the daughter of a Scotchman who had come South" from the ancient kingdom of Fife. The Christian ame given to the subject of this sketch was the result of an attempt n the part of his parents to find a compromise between the two ational religions in which they had been respectively brought up.

As a boy Judd showed a strong predilection for the study of ience. His interest was first directed to astronomy, and having ade a telescope with cardboard tubes for himself, he spent many f the night hours in observing celestial objects; this pursuit led im to devote much of his time to mathematical studies. At a later ate, however, geology began to attract his attention, and the eading of Lyell's "Principles of Geology" appears to have etermined his devotion to that science.

When only 4 years old the lad lost his mother, and before he eached the age of 8 his father removed to London, having received n appointment at Somerset House. The boy's school life, which ad commenced at Portsmouth, was continued at Camberwell, and hen the time for leaving school arrived his fondness for study led im to adopt the teaching profession. In 1858 he entered a training ollege at Westminster, but in the following year an opportunity eemed to present itself for taking up more purely scientific work han lies in the way of an elementary teacher. The newly-formed epartment of Science and Art instituted in 1859 an experiment in he direction of securing teachers of science by awarding certificates s the result of examination. Judd entered for these examinations n the subjects of geology and mineralogy, and obtained first-class ertificates entitling him to teach these sciences. Unfortunately, owever, the demand at that time for scientific instruction was too limited to justify the enterprise on the part of the Science and Art Department, and it was soon abandoned. Judd, after some futile attempts to obtain employment as a teacher of science, resigned himself to the work of general, elementary teaching and became master of a school at Horncastle in Lincolnshire. Here, however, he spent all his spare time in scientific studies, devoting the greater part of his nights to work in a small chemical laboratory which he had fitted up in his house. His holidays during three years' residence in Lincolnshire were spent in rambling about the county and making himself acquainted with its geological features.

Although the examination for the teachership in science led to no direct practical result, yet it proved the turning-point in Judd's career by introducing him to the notice of the two examiners—his subsequent friends and colleagues, Professor (afterwards Sir Andrew) Ramsay and Mr. (afterwards Sir Warington) Smyth. These geologists, after the perusal of the young candidate's papers, both communicated with him, giving him warm encouragement and offering their assistance if he came to the Royal School of Mines to continue his studies.

It was not, however, till the beginning of 1863 that Judd found himself able to accept the invitation. He then entered the Jermyn Street School by passing the examinations of the first two years with the object of taking the courses of the third year. It was, however, possible at that time to attend all the series of lectures during one year, and very gladly he availed himself of the opportunity of listening to the discourses of Hofmann, Tyndall, Huxley, Ramsay, Smyth, Percy, and Willis, as well as to occasional lectures by Owen, Jukes, and others. At the end of the third year Judd, instead of sitting for the Associateship, became a candidate for one of the newly instituted Royal Exhibitions. This he did in the hope of being able to spend three years in higher studies and research. But on winning the exhibition he found that no arrangements could be made, within the circumscribed limits of the Jermyn Street building, for such advanced work, and he somewhat reluctantly accepted an offer to become analytical chemist in the iron and steel works of Messrs. Cammell & Co. at Sheffield.

The residence of Judd at Sheffield, though limited to less than a year, exercised a very important influence upon his future career, for it was there that he formed the acquaintanceship of Henry Clifton Sorby, who became his lifelong friend. Mr. Sorby taught him to make thin sections of rocks, and fully impressed upon him the value of this method of research. This was in the year 1864—a period when the microscopic study of rocks had attracted but little attention either in this country or abroad. The residence at Sheffield was brought to a sudden end by a railway accident in which Judd nearly lost his life.

After many months of confinement to a sick bed, Judd was ordered by the doctors to abstain from settled employment for some years, and he gladly availed himself of the opportunity to return to Lincolnshire and devote an out-of-door life to continuing the geological studies of the county which he had already commenced. The result of these labours was seen in two noteworthy additions to geological knowledge. In the first place, he was able to show that the strata which form the base of the Lincolnshire Wolds—which had been vaguely referred either to the Jurassic or the Lower Greensand—are really representatives of the Neocomian of the Continent, and an examination of the Speeton Clay of Yorkshire proved that all the zones shown to exist in Lincolnshire are present there also under different mineral conditions. In the second place, a study of the fossils in the great belt of oolitic limestones running north and south through the county of Lincoln, and continued southwards into the Midlands and northward into the East Riding of Yorkshire, demonstrated that these rocks are of *Inferior* Oolite age, and not Great Oolite, as had hitherto been supposed. His work in Lincolnshire was varied by trips to the Continent, where, with knapsack on back, he visited and studied the various equivalents of the Lincolnshire strata.

Among those who were specially interested in the results of this work was the amiable Oxford professor, John Phillips. Phillips made the suggestion that Judd should complete a geological map and memoir on Lincolnshire, as he had himself done for Yorkshire. But, on the other hand, Professor Ramsay urged Judd to accept a temporary post on the Geological Survey, promising him the opportunity of surveying the districts south of Lincolnshire, where his previous experience would be of special use. He accordingly joined the Survey in 1867, and for four years was engaged in the survey of Rutland and parts of the adjoining counties. The result of this work was to demonstrate the necessity of a revision of the whole of the Lower Oolites of the Midland districts as far south as Oxfordshire and Gloucestershire. Over the whole of this area the rocks hitherto mapped as Great Oolite were re-mapped as "Lincolnshire Limestone" and "Northampton Sand," and placed in the Inferior Oolite, while the limits and divisions of the true Great Oolite were defined. During this period Judd was able to apply the methods which had been taught him by Sorby to the investigation of the nature and origin of the ferruginous rocks of the Northampton Sand. His paper on the subject, containing a full discussion of the microscopical and chemical characters of the rocks, was read before the Geological Society in March, 1869, but was withdrawn in consequence of a new regulation being made that such papers must appear in the Survey Memoirs. It was at last published, but without figures, in 1875.

A former colleague and fellow-worker on the Geological Survey for many years writes of his work as follows:—

"Professor Judd joined the staff of the Geological Survey in 1867, and was occupied during three years in the county of Rutland and bordering portions of Leicestershire, Lincolnshire, and Northamptonshire, that are included in Sheet 64 of the old series map.

"In the course of his investigations he proved beyond question that the important group of limestones which form 'the cliff' of

Lincolnshire belong to the Inferior Oolite, and not to the Great Oolite as had been generally believed. Much confusion had arisen through the correlation of the Collyweston Slate with the Stonesfield Slate. These and other matters connected with the stratigraphy of the Lower Oolites, and especially with the age and relations of the Northampton Sands, were clearly expounded by Professor Judd. The acceptance of his views necessitated the revision of some of the previously published maps of the Geological Survey, and during the last year (1870–71) he was occupied on the Geological Survey he carried his revisions as far as he was able from the neighbourhood of Northampton into parts of Oxfordshire; but much yet remains to be done in the area near Chipping Norton.

"The description of Sheet 64 was written by Professor Judd in the memoir on 'The Geology of Rutland,' etc., issued in 1875 by the Geological Survey. This memoir contained an important Introductory Essay, 'On the Classification of the Jurassic Strata of the Midland District, and their Correlation with those of the Cotteswold Hills and the North-East of Yorkshire respectively.' In this essay, as pointed out, some of the views had been foreshadowed in previous writings by Brodie, Lycett, and to a certain extent by Morris, while Samuel Sharp of Northampton and Thomas Beesley of Banbury had concurrently been working on the Lower Oolites in their respective districts, and had been 'independently led to similar conclusions' with regard to the Lincolnshire Oolite and Northampton Sand. Nevertheless, the whole subject was dealt with by Professor Judd in a masterly way, and his original observations not only placed the subject on a sound basis but formed the guide to all subsequent workers in the Midland area."

The special work for which Judd had joined the Survey having been completed, he accepted an offer from his friend Mr. Matthew Arnold, in 1871, to join the Education Department for a time, and to act with him as an Inspector of Returns under the Education Act of 1870. For over a twelvemonth he was engaged in inspecting elementary schools and training colleges in the London area between Westminster and Edmonton. Geology was not, however, entirely neglected during this period, for he had undertaken to furnish the Geological Survey with a memoir on the districts he had surveyed in Rutland, etc., with an essay on the classification of the Lower Jurassic Strata of the Midland district. This work was published in 1875. At this period, too, he was led to pay a considerable amount of attention to the question of the age of the Wealden formation and its relations to the strata above and below it, the Jurassic and Neocomian.

Released from the work of school inspection, Judd returned with zest to geological pursuits. The patches of Jurassic strata in the north-east of Scotland attracted his attention, and, after two years of hard work in the district, he was able to show that these patches of Mesozoic strata owe their preservation to the action of great faults, by which they had been let down among the older and harder rocks. He also, with the aid of Dr. Joass and Dr. Gordon, collected the fossils of the various beds, and showed the exact age and relations of the whole series from the Trias to the Upper Oolites.

The study of the Mesozoic strata of the east coast of Scotland naturally led to the examination of the equivalent beds in the western coasts and islands, and here Judd, in addition to working out minutely the succession of Jurassic and Triassic rocks, was able to show that interesting representatives of the Carboniferous and Cretaceous systems—the presence of which had been hitherto quite unsuspected—actually occur in these Western Highlands.

The preservation of patches of younger rocks in the west of Scotland, while as in the eastern area partly due to the action of great faults, is to a still greater extent the result of the protection afforded by the vast masses of igneous rocks with which they are associated. Judd's attention was therefore soon directed to the unravelling of the complexities of these rock-masses, and of their relations to the Mesozoic strata. The task was at the time one of great difficulty, for no Ordnance Maps of the district had been published, while the facilities for travelling in the district, especially to a man of small means, were far less than even at the present day.

Macculloch had demonstrated that these igneous rocks are of later date than all the Secondary strata with which they are so closely associated, while Zirkel had proved that among the rocks of Skye true granites and gabbros occur. Other writers, however, had maintained the Jurassic age and a metamorphic origin for these rocks. The result of Judd's work was to establish the fact that between the most perfect granites and gabbros there exists every gradation, to rhyolites and pitchstones on the one hand, and to basalts and tachylytes on the other hand; and thus that the distinction between 'plutonic' and 'volcanic' rocks is a purely artificial one. That all these igneous rocks must be of Tertiary age he proved by showing that they overlie and are intrusive in the youngest Cretaceous strata (Chalk of the Zone of *Belemnitella mucronata*).

As the result of a general survey of the igneous rock-masses, he was able to state that they indicate the existence of five centres of eruptive activity—the sites of great Tertiary volcanoes; and that concerning the dimensions and history of these volcanoes important evidence can be obtained; the extinction of these great volcanoes was shown to have been followed by sporadic outbursts all over the area. He maintained that the general order of succession in the eruption of the igneous materials was from the acid to the more basic varieties.

The results of this work in the Western Isles of Scotland attracted much interest among geologists, and the veterans of the science—Lyell, Darwin, and Scrope—were warm in their praise and kindly in their encouragement and aid. In 1874 Sir Charles Lyell, then nearly blind, invited Judd to spend part of the Summer at his home in Forfarshire and to visit and talk over many of the scenes of the master's early labours, while helping to revise a new edition of the "Elements of Geology." After the death of Lyell, Darwin used to invite Judd from time to time to meet him and discuss current geological topics. Scrope, at this period too old and infirm to undertake further travels, sent Judd to visit the different volcanic districts of Europe, which he himself knew so well, aiding him the while by conversation and correspondence. Never surely was young geologist so fortunate and happy in securing the friendship and teaching of men like Lyell, Darwin, and Scrope!

As the results of his travels over Europe, Judd published a series of papers under the title of "Contributions to the Study of Volcanoes." He also read before the Geological Society a paper on the ancient volcano of Schemnitz. In his earlier memoirs he had been content to adopt Bunsen's classification of rocks in an Acid and a Basic series. He now, however, showed that such a simple classification was beset with difficulties, and proposed the term "Intermediate" for that extensive class of rocks which could not be conveniently assigned to either of Bunsen's classes. The French geologists, later, adopted the same plan, calling the intermediate rocks "Neutral." At a later date Judd proposed the separation of the smaller group of "Ultrabasic rocks" as a distinct class. His study of the contemporaneous volcanic rocks of Bohemia and Hungary led to the recognition of the fact that a geographical distribution of rocks exists, not less marked than that of animals and plants, and this idea crystallized in the suggestion of the term "petrographical province," which is now so universally adopted. While travelling over the volcanic districts, Judd was able to send to his friend Professor Story Maskelyne large collections of rock-specimens, which were deposited in the Mineral Department of the British Museum.

During his journeys upon the Continent for the purpose of studying the volcanic rocks, Judd never lost sight of the importance of making himself acquainted with the best methods of teaching science. His frequent intercourse with his former teacher and constant friend—Professor Huxley—had led him to recognize the supreme value of practical teaching in science, and, while visiting the various universities and mining schools of the Continent, this point was kept constantly in view. In 1876 the opportunity of taking up the teaching of geology arrived, through the resignation by Sir Andrew Ramsay of the professorship of geology in the Royal School of Mines on his appointment to the Directorship of the Geological Survey. By the unanimous vote of the Council Judd was recommended for the vacant post, and at once entered on its duties.

After lecturing for a year at Jermyn Street, it was found that the impossibility of obtaining laboratory accommodation necessitated the removal of the geological division to South Kensington, to which place most of the other divisions of the school had already been transferred, and in 1881 the sphere of work of the school was enlarged by the creation of the Royal College of Science. Here, with the assistance of Huxley, Judd organized a system of practical teaching in geology, similar to that already established for biology, and this system during the next twenty-five years was gradually developed with the co-operation of able students, who became his assistants, among whom may be especially mentioned Professor Cole, the late Mr. A. V. Jennings, Dr. W. F. Hume, Mr. T. H. Holland, Dr. Evans, Dr. Cullis, and Professor Skeats.

In 1878 Professor Judd married Jeannie Frances Jeyes, a niece of his old friend and fellow-worker in the geology of the Midlands —S. Sharp, Esq., F.S.A., F.G.S. In 1877 he was elected one of the Secretaries of the Geological Society, and served that office for ten years till he was elected President, during the years 1886 and 1887. He had received the Wollaston Fund in 1868, and in 1891 was awarded the Wollaston Medal.

During nearly thirty years that he has been engaged in teaching, only the Summer vacations have been available for field-work. But in these vacations the igneous rocks of the Western Isles and other parts of Scotland have been examined and the collections made subsequently studied in the laboratory. The results have been published in a series of petrographical memoirs in the Quarterly Journal of the Geological Society. Teaching the science with London as a centre, all questions concerning the geology of the London Basin were naturally of special interest to him, and thus he was led to the publication of papers on the geology of the London and Hampshire Basins and the correlation of their strata. With the aid of a pupil, the late Mr. Collett Homersham, he was able to study the materials obtained in a deep boring at Richmond, and to show that there, and also in the deep well at Meux boring in the Tottenham Court Road, richly fossiliferous deposits of Lower Oolite age occur.

One who has known Professor Judd for many years, and is competent to judge of the value of his work as a geologist, writes :—

"The breadth and accuracy of Judd's knowledge is the characteristic which from the first has most impressed me. Trained in youth as a practical chemist, well grounded at the Royal School of Mines in physics and biology, early to appreciate the importance of the microscope in the study of rocks, with his experience in the field as a worker on the staff of the Geological Survey greatly widened by study of some of the most interesting districts on the Continent, he could deal with all sides of a problem, whether petrological, or physical, or palæontological, and he contrived, notwithstanding the incessant demands of educational work in later years, to keep well up to date in the literature of the science. He has made—and this can be said of very few—valuable contributions to all departments of geology, and in proof of this I need only recall papers in the Mineralogical Magazine, such as that on Scapolite, those in this periodical on glacial questions and on volcanoes, afterwards developed into his well-known book, those, chiefly in the Quarterly Journal, in which he dispelled the fog which obscured our Neocomian deposits, his memoir on the geology of Rutland, and the papers on the west coast of Scotland, which, whether the verdict on one point be ultimately for or against him, will always rank as classic.

In fact, whatever work he has done, whether scientific, educational, or administrative, has always been characterized by a careful observation, a conscientious thoroughness, and an earnest desire to arrive at the truth."

When Professor Huxley retired from his professorship in the Royal College of Science in 1885, he retained the post of Honorary Dean, but many of the duties of the office were undertaken by Professor Judd, who on the death of Huxley in 1895 was made Dean and created a C.B. He was elected a Fellow of the Royal Society in 1877, and has served twice for periods of two years each on the Council, acting as a Vice-President of the Society in 1902 and 1903. In 1887 he was President of the Geological Section of the British Association at the Aberdeen meeting, and some years subsequently had the honorary degree of LL.D. conferred upon him by the University of that city. He has acted for a considerable time as Chairman of the Seismological Committees both of the British Association and the Royal Society, and is Foreign Secretary of the Mineralogical Society.

While educational, official, and other duties have necessarily limited his opportunities for research during recent years, he has found time for study of materials obtained by boring in the Nile Delta, for work upon the products of the great eruption at Krakatoa, on the rocks brought home from the Ruby district of Burma by Mr. C. Barrington Brown, and especially on the cores and other specimens obtained in the boring in the Coral-reef of Funafuti. Various incidental questions like those of the nature of Sarsens, the materials employed in the building of Stonehenge, the nature of the rocks forming Rockall, with problems arising out of the study of rock-forming minerals, have engaged his attention and formed the subject of numerous papers. Of larger works for students he has written a revised edition of Lyell's Elements under the name of "The Student's Lyell"; "Volcanoes: What they are and what they Teach"; a translation, with introductory notice, of Behren's "Microchemical Analysis"; and critical introductions to Darwin's geological books, one of these having been translated into French by his old friend Professor Renard.

From the teaching work, which has occupied so much of his time and energies during nearly thirty years, Mr. Judd has now just retired, having reached the age limit. Many hundreds of his students now occupy important teaching posts or are engaged in the geological surveys of our own country, the Colonies, India, and Egypt, while still more are engaged in mining and metallurgical work in all parts of the globe.

One of his old Assistants who knows his methods of teaching, and has gone through the work of the Royal College of Science with him, writes:—

"As a teacher of geology Professor Judd holds a position of the highest distinction. The courses of instruction designed and gradually evolved by him have long been regarded as among the most perfect and complete of their kind. He was one of the very first to introduce into the academic curriculum systematic practical instruction in the subject, and of the many excellent courses in geology now open to students in various parts of the world, not a few are based, wholly or in part, upon the methods originated by him and carried out so ably and for so many years in the Royal College of Science.

"Throughout his career as a teacher of science Professor Judd has been an enthusiastic advocate of the system employed in the Royal College of Science of enabling the student to concentrate his whole attention upon one subject at a time, instead of requiring him to study several different and not necessarily cognate subjects simultaneously. He has also strongly upheld the principle of making practical teaching in the laboratory strictly sequential to, and directly illustrative of, the lectures. In his own department, whenever possible, the laboratory work has been arranged as an immediate extension of the lectures, in which the student has had an opportunity of examining systematically and illustrating experimentally such data and principles of the subject as are capable of exemplification in this manner; and it is doubtless to this excellent system of simultaneous theoretical and practical work that the very real knowledge of their subject which has characterized such a large proportion of his pupils has been mainly due. Another feature which has determined the success of Prof. Judd's teaching is his freedom from conservativism: if the advances made in his subject or in any branch of it have pointed to the desirability of changes in the method of its presentation to the student, he has never shrunk from the abandonment of methods already adopted or from such wholesale reconstruction of his courses as may have seemed necessary to bring them into touch with the most recent views.

"The relations between Professor Judd and his students have always been of the pleasantest and most cordial kind. He has invariably taken a keen personal interest in all who have come under his charge, and has always been ready to help and advise them, not only in their geological studies, but also in all matters connected with their college life and their future career. He was constantly invited to act as an officer of the many clubs and societies of the college, and in such a capacity always set an excellent example to those associated with him by the very conscientious manner in which he performed the duties which his acceptance of office entailed, notwithstanding his very heavy duties as Professor and Dean. These and many other traits endeared him to the students, among whom he was very popular, and by whom he was regarded with great respect and esteem. It must be a constant source of pleasure to him to feel that the many hundreds of students who have passed through his hands, and who are now distributed all over the world, will always entertain the pleasantest recollections of their association with him; they will learn with regret that he has relinquished the post which he has filled so long and honourably."

LIST OF SCIENTIFIC PAPERS AND BOOKS BY PROFESSOR JOHN W. JUDD.

1867. “On the Strata which form the base of the Lincolnshire Wolds”: Quart. Journ. Geol. Soc., vol. xxiii, pp. 227–251.

1868. “On the Speeton Clay”: Quart. Journ. Geol. Soc., vol. xxxiv, pp. 218–250.

1869. “On the Origin of the Northampton Sand.” This paper was read at the Geological Society on March 10th, 1869, and an abstract of it appeared in the Phil. Mag., vol. xxxviii, pp. 400–401. Its publication was undertaken by the Geological Survey, but was delayed till 1875, when it appeared as chapter vi of the “Geology of Rutland,” pp. 113–138, but without illustrations.

1870. “Additional Observations on the Neocomian Strata of Yorkshire and Lincolnshire, with notes on their Relations to beds of the same age throughout Northern Europe”: Quart. Journ. Geol. Soc., vol. xxvi, pp. 326–347.

1870. “On the use of the term Neocomian”: Geol. Mag., Vol. VII, pp. 220–227.

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II.—The Chalk Bluffs at Trimingham.

By Professor T. G. Bonney, D.Sc., F.R.S., and Rev. E. Hill, M.A., F.G.S.

(PLATE XXII.)

THE huge masses of chalk in the glacial drift on both sides of Cromer, and especially at the headland near Trimingham, have for many years attracted the attention of geologists. In this Magazine (Dec. II, Vol. VII, 1880, p. 55) and in the Survey Memoir on the Geology of the Country around Cromer, published in 1882, Mr. Clement Reid ascribes those at the latter place to the advance of an ice-sheet by which the chalk has been thrust up into a kind of fold and the flint layers have been bent, illustrating his interpretation by a diagrammatic section. We visited the Cromer cliffs for the first time in 1892, and after a careful examination of the Trimingham headland, not only felt more strongly than before certain weak points in Mr. Reid's reasoning, but also observed some facts difficult to reconcile with his conclusions. Since that date we have more than once visited these sections, and found last April that comparatively recent inroads of the sea had made great changes which had shown the relations of the chalk and glacial drift to be, in our opinion, incompatible with Mr. Reid's interpretation.

In 1892 two separate masses or 'bluffs' of chalk, as he describes in the Memoir (p. 95), were exposed in the drift at the base of the cliff near Trimingham. In the western of these the bands of flint were contorted, though not quite as represented in his diagram (p. 116), for the top one was again bent up on the land side. Above, and to some extent behind it, was a bed of bluish-grey boulder-clay[1] with no sign of contortion beyond its occurrence in these two positions, which here and there was parted from the chalk by a thin layer of coarse gravel. Over the clay came a bedded sand with much internal contortion, and above this a second boulder-clay (rather browner in colour and less pebbly) lying apparently even and undisturbed. The chalk bluff ended landwards on both sides in an almost vertical wall (if anything, slightly overhanging). The drift beds on the eastern side were a little more confused than on the other; the upper boulder-clay seemed slightly more laminated, and the lower one was rather thicker.

The eastern bluff was divided into two masses, one about 30 feet, the other about 50 feet long, by a V-shaped gully, about 10 feet wide, filled with laminated clay. At its ends the flint bands, so far as they could be seen, showed no contortion, nor did the drift beds above appear 'rucked up.' In fact, we saw no indication of what might have been expected if, after at least some of the glacial drift had been deposited, a great ice-sheet had, as it advanced, pushed up the chalk in a sharp fold, and the following note written at the time by one of us (T. G. B.) expresses our conclusion:—"After prolonged examination I am convinced (with Hill) that C. R. is wrong in his interpretation of the record; that there is no contortion,[2] and that the mass of chalk is a boulder."

One of us (E. H.) visited the section in the Spring of 1898 and of 1899. On the former occasion he noted on the top of the western boulder a bed of gravel, "probably débris of denuded chalk before transport," and on that of the eastern one a bedded sandy clay filling up its inequalities, and overlain by bedded sands, which were seen to rest on the chalk at its northern end. On the latter occasion he wrote: "The chalk bluff is probably much wasted. Now there is no vertical bedding on the higher cliff, only in a low mass at the east end the beds seem, though not very clearly, to be steep. Of the boulder-clay but little is left, and that is covered by blown sand, but the beds have the appearance of being deposited round the mass, not crushed up with it." On this occasion he also saw a mass of chalk, exposed at the base of the cliff and rising from the shore, some six or seven hundred yards on the Cromer side of the Trimingham headland, about seventeen yards long, and, so far as he remembers, not more than four high, the beds of flint curving down very gently towards its eastern end. This mass had not been visible in 1898, nor was it in 1905, having probably been washed away in the interval.

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[1] We prefer this more general term to that of till, by which it has generally been designated in the Cromer sections. Though the latter is no longer used to imply an indubitable product of land ice (a very convenient distinction), some remnant of that connotation still clings to the word, and besides this we are unable to see in what important respect (except an occasional more distinct appearance of stratification) these glacial clays near Cromer differ from similar English deposits to the north, south, or west.

[2] Meaning such as is figured in the Memoir. Throughout we paid more attention to the western bluff (hence the above use of the singular) because the bent flint layers in that made it the mainstay of the hypothesis.

We were again at Cromer in the Spring of 1900, and twice visited the Trimingham section.[1] The drift about the western chalk-mass was much obscured by washed down mud, but the curvature in the bands of flint was very distinct at the eastern end and less so at the western, though apparently in the latter case more acute than in the former. At the eastern chalk-mass a small 'cave' was seen high up on its western side between it and the drift, but the section was on the whole clearer on the opposite side. In this mass the flint bands were practically horizontal. Its top, rather wavy in outline, was covered by a thin irregular bed of coarse gravel, curving over its rounded corner. Then came sand enclosing a thin bed of laminated clay, followed by a rather thicker one of bluish-grey clay, and that by alternating beds of sand and clay, the whole being rather less than three yards in thickness. From the place where the edge of the chalk-mass plunged steeply downwards a crack extended vertically upwards into the drifts. The beds on the land side of this were to a considerable extent masked by 'wash-down,' but, so far as we could see, were not continuous with those on the other which have just been mentioned. Gravel was also seen to rest on a sort of ledge near the bottom of the chalk-mass, followed by a rather sandy band; this, by a thinner one of brown laminated loam, and it by a slightly thicker bed of sand, covered by a clay "resembling the thicker bed of bluish-grey clay seen at the top." This clay "contained some pebbles and bits of chalk besides flint, but was not quite identical with the usual boulder-clay."[2] There was also a small hollow in the steep shoulder of the chalk-mass filled with "laminated stuff, rather messed." As these beds curved upwards they might be cited to prove a bending simultaneous with that of the chalk. But unfortunately for this the lower set overlapped one another and ended against the chalk, while the flints in the latter afforded no evidence of curvature, but apparently dipped gently towards the south or south-south-west. The sea-face of the mass was then about 33 yards in length, its sides being also exposed to view. But on this occasion a third mass of chalk, about 12 yards long, was disclosed about 33 yards to the east of the last-named, on the top of which was the usual boulder-clay, of which a few feet were exposed.

[1] One of us (T. G. B.) records in his diary that this chalk-mass seemed to be included in the boulder-clay which cropped out on the shore about four yards to the west; that it contained *Belemnitella mucronata*, and that the flints, though rather discontinuous, seemed to form a C-like curve (on this detail, however, we were not quite agreed). He records chalk as exposed to west and to east of the eastern mass, but whether connected with it or as separate boulders could not be determined.

[2] Two varieties of boulder-clay occur in the Cromer district, one of a bluish-grey colour, another rather browner, more sandy, more distinctly stratified, and sometimes less pebbly. West of Cromer the latter is the commoner; east of it, on the whole, we think, the former, which is often the lower in position, but sometimes the one seems to pass into the other, or even to replace it.

Our final visit was in April last, when we found that the aspect of this part of the coast had been greatly altered by inroads of the sea. The western bluff (A),[1] so often noticed above, was now partly isolated, apparently reduced in length and height, and altered in shape, for another mass of chalk (C), almost separated from the former by a kind of passage, filled with the usual boulder-clay (B), had been disclosed to the south-west, roughly speaking. The south-western flank of this curved gradually down to the beach, as is well shown in the photograph, having a wedge-like termination, the lower side of which was seen to rest (D) on the usual greyish boulder-clay. Still more west and rather south of this, was a slab-like mass of chalk (E). As the two are only a few yards apart they might have a hidden connection underneath the beach, but we thought this improbable, for while they dipped on the whole towards each other, they did not appear to form part of a regular syncline. This last mass of chalk rests against and overlies the usual boulder-clay (F). In the remnant of the original western chalk-mass the flint bands showed, as we thought, a sharp curvature in the lower part of that face, and on its eastern one curves more like part of a quadrant. On this side a bed of chalky gravel rested against the landward face of the chalk, and parallel with the former was a distinctly stratified bed in the boulder-clay (that filling the 'tunnel'). These bands were parallel with the edge of the chalk and dipped seawards at a high angle. Also they made an angle of some 30° with the tangents to the curves of the flint layers at their nearest parts. Thus they can hardly be cited to prove a 'rucking up.' The chalk lintel of this portal varied irregularly in thickness from about a foot to about a yard, and seemed to be continuous,[2] but we came to the conclusion that this tunnelled mass of chalk was more probably formed by two distinct boulders, the wedge-like edge of one resting on the top of the other.[3] The eastern mass, which figured in our earlier descriptions, had now disappeared, unless it were represented by little more than a streak of chalky material at the base of the cliff, together with that which in 1900 we saw beyond it in the same direction.[4]

About a quarter of a mile nearer Mundesley two great boulders of chalk—respectively about sixty and thirty yards long, and about twenty feet high—were exposed in the cliff, rising from the shore,

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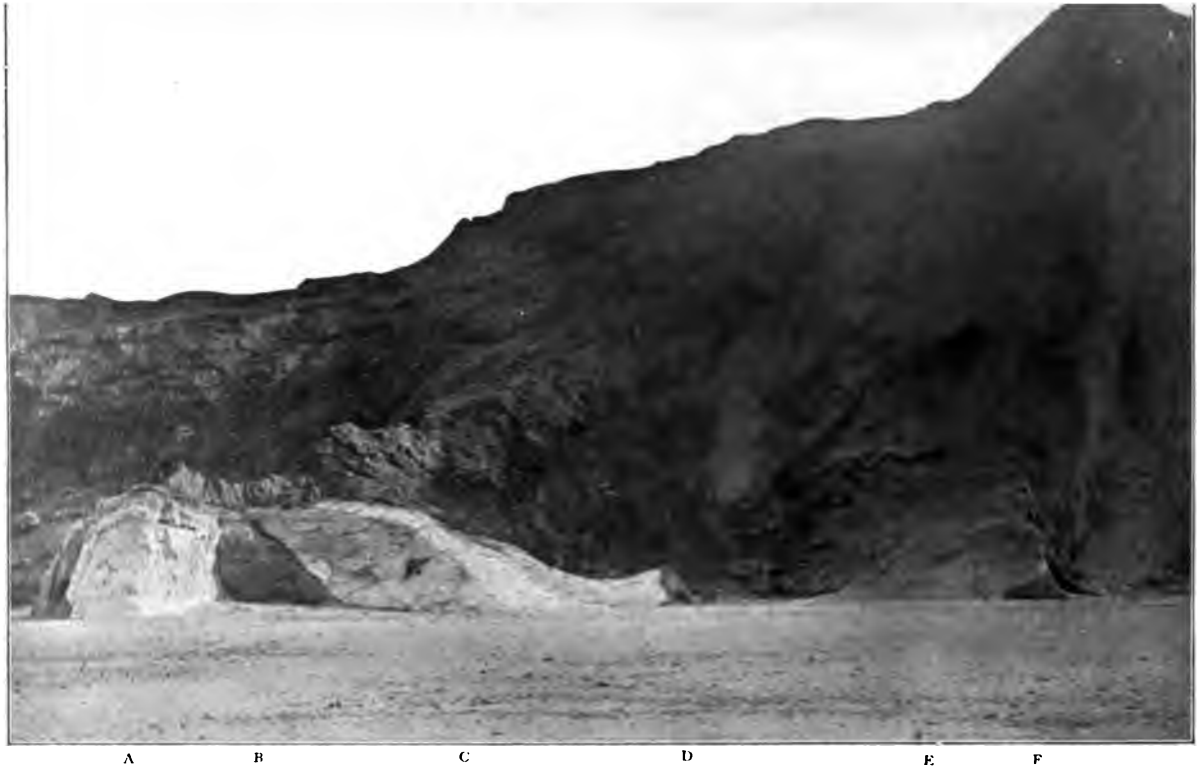
[1] See Plate XXII, a reproduction of a photograph, taken shortly after our visit by Mr. R. T. Mallet, for which and several others of great interest we are indebted to his kindness. By the aid of this our description, we trust, will be intelligible to the reader.

[2] It was not accessible.

[3] Wedge-like ends are not uncommon in these great chalk boulders.

[4] In the neighbourhood of these masses, when the tide permitted (which sometimes it did not), we have seen chalk near one mass, clay near the other, but no proof that they are continuous with the chalk platform, which undoubtedly lies a very few feet below them. A memorandum sent us with the photograph by Mr. Mallet is important. "The foreground is a large mass of blue till, on the level top of which the camera was placed. It was about a foot above the sea at 4 p.m. on May [illegible]." (About an inch vertical of this foreground has not been reproduced in the Plate, or otherwise the scale must have been diminished.)



THE "WESTERLY CHALK BLUFF" AT TRIMINGHAM.

From a photograph by E. T. Mallet, Esq.

he flint bands in which were nearly horizontal. On the top of each vas a layer of coarse gravel, followed by much stratified sand with occasional bands of clay. The eastern of these boulders projected lightly in advance of the western one, and their ends, so far as the lipped material allowed us to determine, were about nine yards part.[1] The clay just mentioned is not pebbly, but below high-vater mark and perhaps eight feet vertically beneath the base of he cliff typical boulder-clay was exposed on the beach. About ifty yards to the east chalk showed up beneath this, and on it, as ve walked in that direction, we saw for a considerable distance atches of boulder-clay. Evidently ancient denudation has removed he Forest Bed and *Leda myalis* sand from this part of the coast, so hat for a considerable distance the bluish-grey boulder-clay rests on very slightly irregular surface of chalk.

We may now mention one or two fundamental weaknesses which, o our minds, were inherent in Mr. Reid's hypothesis from the first, ut had apparently escaped his notice. He offers his readers only one lternative to the action of an ice-sheet as an explanation of these halk-masses either at Trimingham or where they are admittedly oulders, viz. transport by icebergs, and dismisses the latter on the round that the sea, supposing it to have existed, would have been oo shallow to be navigated by bergs of sufficient thickness to float uch huge masses of rock. We do not dispute this objection, but re surprised to find that he has not discussed or even noticed olonel Feilden's observations on the transporting power of an cefoot—i.e. of 'rafts' of ice—which were made in Smith Sound luring Sir G. Nares' Arctic expedition.[2] Such rafts, as the chalk-nasses need not have travelled far, would be much more probable ehicles than bergs.

Again, the reader must remember that the section in the Survey Memoir (p. 116) exhibiting the Trimingham mass as a second stage n boulder-making is only hypothetical, as its author virtually dmits in the following sentences (p. 115):—"If the ice-sheet, nstead of flowing over the beds, happens to plough into or abut gainst them, it would bend up a boss of chalk, as at Beeston. A more extensive disturbance, like that at Trimingham, drives efore it a long ridge of the beds, and nips up the chalk, till, like cloth creased by the sliding of a heavy book, it is folded into an nverted anticlinal. A slight increase of pressure and the third tage is reached—the top of the anticlinal being entirely sheared off, he chalk boulder driven up an incline and forced into the overlying oulder-clays." An explanation no less clear than confident, but an any instance be cited which affords even an approach to a valid roof that either a large glacier or an ice-sheet can exercise this rooting' power on a fairly solid rock. Statements such as that ust quoted are no doubt common; ice has been credited with the xcavation of valleys, fjords, and important lake basins, but when we examine that still in existence, or the districts which it formerly covered, we find it has never done more to a limestone than mould its surface into mound-like masses, and has often preferred to let a gravel severely alone. In the Cromer district, as at Möen, Rügen, and the Isle of Wight, the chalk has undergone considerable flexure, but that this was done in Glacial times is nothing but an hypothesis, contrary to, rather than supported by, such evidence as can be obtained. We have more than once examined the chalk platform between Beeston Hill and Sheringham, and consider those little insulated outcrops of that rock, rising a yard or two above the beach, to be far more probably the indirect result of pre-Glacial, perhaps long pre-Glacial, disturbances, which were afterwards exposed to marine denudation probably in late Pliocene times. Even the case figured in the Survey Memoir (at the bottom of p. 115) is not in the least convincing. The Pliocene beds might have been deposited round an old bank of chalk, just as is shown in the section, and the fact that the higher of the flattened arches of flint comes to an end at the upper surface is more consistent with flexure followed by denudation than with the bending of a rock-mass, which had a practically level top and horizontal flint bands. Still less can it be proved that an ice-sheet has ever produced by its thrust an 'inverted anticlinal,' even in a rock no harder than chalk, or is competent entirely to shear off the top of that anticlinal. Allegations of such things can, no doubt, be produced by the dozen, but in all of which we know anything hypothesis takes the place of proof. Mr. Reid himself cites one (p. 115): "By Continental geologists the theory (we should call it hypothesis) has been already applied to the explanation of the even greater disturbances in the island of Möen in Denmark." So it has been at Rügen, which also we have carefully studied,[1] with the result that we found it difficult to treat the explanation seriously. Did we admit its validity we should be fully prepared to attribute the disturbances of the chalk at the Needles or Culver Cliffs to the thrust of an ice-sheet!

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[1] A third and smaller chalk-mass was exposed in the cliff about twenty yards still urther east.

[2] Quart. Journ. Geol. Soc., vol. xxxiv (1878), pp. 563–566.

Perhaps, however, the huge and strangely-shaped boulder now visible in the cliffs between East and West Runton Gaps will be cited as a proof of the bending powers of an ice-sheet. Here a mass of chalk, which must once have been slab-like, after lying almost horizontally for some fifty yards at the bottom of the glacial deposits, bends rather suddenly[2] and runs rapidly up the cliff to within a short distance of the top. It is capped, as is not unusual with the Cromer erratics, by a band of coarse flint gravel, which can be seen, at any rate for a considerable distance, to be bent up with the chalk. This mass, we may be told, has been sheared off, thrust against some obstacle, and finally bent up by the advancing ice-sheet. If so, the direction of the axis of the curve shows that ice-sheet to have been coming from somewhere between west and south rather than north or east—a mighty volume of frozen water, not from Scandinavia or Scotland, but from the mountainous region which environs the Wash!

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[1] Quart. Journ. Geol. Soc., vol. lv (1899), p. 305, and vol. lvii (1901), p. 1.

[2] It takes the shape of a fairly open hook, the two arms forming rather less than a right angle; the 'horizontal' part of it slopes slightly westward; a thin extension of a rather sandy boulder-clay dies out beneath it, and then the chalk *probably* touches (this part was masked by some talus) the *Leda myalis* sand.

We conclude by recapitulating, in addition to these more general objections, the heads of the evidence, which, as shown above, we have collected during our visits, and find irreconcilable with Mr. Reid's hypothesis:—

(1) The bending of the chalk, as shown by the flint bands, is very variable (notably at Trimingham headland), and not seldom practically disappears, affording no evidence of regularity of distribution.

(2) The chalk in immediate association with the glacial drift does not occur, even at Trimingham, as a continuous mass, but in separate fragments.

(3) The bedding of the drift, where in contact with the chalk, is generally almost, if not quite, horizontal; at any rate, it shows that this lower part cannot have been crushed up *with* the chalk.

(4) But above these horizontal beds others may occur which are contorted, and sometimes to an extraordinary extent. Thus their flexures must be due to some other cause than that which Mr. Reid invokes to produce the bending and uprooting of the chalk and immediately adjacent drift; for if a second advance of the ice-sheet be postulated in explanation of these, it was content, on the second occasion, to leave the drift below it undisturbed.

(5) Lastly, chalk-masses occur east and west of Trimingham headland, insulated, like great erratics, in the drift without any appearance of crumpling up, so those at that place do not demand a special explanation.

Thus Time, as we venture to maintain, has delivered its verdict against an hypothetical interpretation of these Trimingham masses, which in our opinion ought not to have found a place in a Survey memoir. They are simply huge boulders, like the other chalk masses east and west of Cromer. We have, of course, adopted for our own use an explanation of these and of the extraordinary contortions of the drift; but as we do not yet exalt it from hypothesis to theory, and as the purpose of this paper is destructive rather than constructive, we think that any definite statement of it would be unnecessary.

III.—Notes on some Rocks from New Zealand.

By R. H. Rastall, B.A., F.G.S., Christ's Collège, Cambridge.

THE specimens on which the following notes are based were collected by Mr. H. T. Ferrar, M.A., F.G.S., while on a tour through New Zealand, during the time the "Discovery" was being overhauled in Lyttelton, on her return from the Antarctic. The topographical and field notes were also supplied by Mr. Ferrar, and it must be clearly understood that only the detailed petrographical descriptions are the work of the present writer.

The specimens were obtained near the middle of the North Island of New Zealand, and in the area marked "acidic volcanic rocks" in Sir James Hector's geological map of New Zealand, published in 1883. They all occur in the Taupo zone, the hot-lake district which lies roughly between Lake Taupo on the south and Lake Rotorua on the north.

The following descriptions are written from thin slices cut from Mr. Ferrar's specimens, which were necessarily small, owing to difficulties of transport. The numbering adopted is purely arbitrary, and has no reference to sequence or supposed relative age.

1. *Waiora Valley.*

The Waiora Valley commences in a crater-like depression the walls of which consist of rock No. 61. This depression is about half a mile in diameter, and the walls rise in places to a height of 300 feet. In the centre of the depression there are abundant fumaroles, which deposit sulphur; also pools of boiling muddy water and steam vents; these are causing rapid disintegration of the surrounding rocks.

No. 61. Waiora Valley, Wairaki. This is a dark bluish-grey and rather vesicular rock with distinct porphyritic structure. The conspicuous porphyritic elements are a plagioclase felspar and prisms of pyroxene in a fine-textured groundmass.

The felspar crystals are prismatic or tabular in form and about 4 mm. in length. They are sometimes slightly rounded and show zones of glass inclusions. Zonary banding and twinning on the albite law are conspicuous, and the extinction angles measured on the twin lamellæ are as high as 30° in the interior of the crystals, and nearly 0° in the outer zones, so that the felspar ranges from labradorite to oligoclase. On the average it is of an intermediate composition. The pyroxenes include both colourless augite and pale brown hypersthene with slight pleochroism. The augite is the more abundant. The groundmass consists of a felted aggregate of small irregular prisms of felspar, with a little interstitial glass, the typical hyalopilitic structure of Rosenbusch. It also contains very numerous minute cubes of magnetite.

This rock is therefore a very typical hypersthene-augite-andesite.

2. *Aratiatia Rapids.*

On the Waikato River a series of volcanic rocks crop out through the covering of pumice fragments which cloaks the land. They strike approximately east and west, and the dip is about 60° to the south. The river crosses the strike perpendicularly, and has cut a narrow gorge with sides some 200 feet high. The series is over 1,000 feet thick, and the specimens were collected from the harder bands, which are usually each about 100 feet thick. The foot of the rapids seems to be also the base of the series, and the specimens are described in ascending order.

Nos. 64 and 62 are parts of the same mass of rock near the north and lower side of the rapids. No. 63 was obtained near the middle of the rapids and about a quarter of a mile above No. 62. No. 65 is about a quarter of a mile higher up, and No. 66 is again about the same distance above No. 65. No. 67 was taken from an exposure on the roadside above the rapids and about a mile south of No. 62.

No. 64. A very vesicular rock with a few porphyritic crystals set in a groundmass of reddish and yellowish glass, showing remarkably fine flow-structure.

The phenocrysts are chiefly a slightly zoned plagioclase with a narrow extinction near to oligoclase; but there are also one or two crystals of a remarkable and interesting femic mineral. This occurs in the eight-sided prisms characteristic of the pyroxenes, but its cleavages are unfortunately very indistinct. In colour it is a rather deep reddish-brown and distinctly pleochroic; each crystal has a border of a much deeper colour. The extinction angle is high, up to 40°. More material is required before the mineral can be identified with certainty, but it appears to be a monoclinic pyroxene, very rich in iron, and may possibly be the dimorphous form corresponding to the rhombic ferriferous pyroxene amblystegite. The deep red border may be only a separation of ferric oxide, but its appearance strongly recalls that of the peculiar soda-iron-amphibole, cossyrite, in the Pantellarites. The border is narrow and too opaque for its optical properties to be determinable.

The bulk of the rock consists of a very vesicular glass, varying from colourless to yellow or pale reddish-brown, and showing very fine flow-structures. This encloses a good many minute prisms of felspar. Occasional roundish patches of minute felspar prisms seem to be due to devitrification. A good deal of the glass shows a fragmentary appearance suggesting the inclusion of lumps of glassy tuff in a lava while in motion.

No. 62 is a pink rock very similar to the last, but in addition to the peculiar mineral described above it shows several well-developed prisms of a brownish pyroxene, with a dark border, strong pleochroism, and straight extinction, which may be identified as amblystegite. These two rocks must be regarded as mixtures of lava and tuff of very similar composition, probably indicating a rain of fragments into a lava-flow while still fluid.

No. 63. A markedly spherulitic rock with a few phenocrysts of a zoned plagioclase felspar; coloured minerals are absent, except for a few grains of magnetite. The spherulites may be as much as 3 mm. in diameter, and consist of long regular radiating prisms of felspar, giving a good black cross. They seem to be due to devitrification, since flow-structures, indicated by lines of crystallites, pass through them. This rock also contains rounded lumps of glass of slightly different structure.

No. 65 is practically identical with the last, the only differences being that flow-structure is more pronounced and the spherulites are larger, up to 5 mm. in diameter.

In No. 66 spherulitic and perlitic structures are both very strongly marked, and perlitic cracks pass through the spherulites.

No. 67 is a grey, markedly porphyritic rock with large phenocrysts of plagioclase felspars and a little femic material in a fine-textured groundmass. The felspar is of the usual zoned type, and ranges from andesine to oligoclase. The coloured minerals include both oblique and rhombic pyroxenes, but the latter is dominant; it is very pale brown and slightly pleochroic, so that it must be classed as hypersthene.

The groundmass may on the whole be described as of the hyalopilitic type, but the prisms are not so well defined as usual, and there is a good deal of glass. This rock is a hypersthene-augite-andesite, and strongly resembles the specimen from the Waiora Valley, No. 61.

3. *Huka Falls, near Taupo Lake.*

This rock has horizontal joints, and gives rise to a waterfall some 150 feet high. Its connection with the other rocks of the district is obscured by the post-Tertiary[1] cloak of pumiceous débris.

This is another glassy rock, with rather abundant broken plagioclase crystals and some quartz in a groundmass of fragments of vesicular glass, showing good flow-structures. Coloured minerals are very rare. It is probably more acid than those described above, and may be regarded as a rhyolite tuff.

4. *Tarawera.*

No. 69 was obtained in a roadside cutting near the buried village at the west end of Lake Tarawera, and is said to have been ejected during the great eruption of 1886.

It is composed of fragments of glass, with very fine flow-structures and perlitic cracks, and the usual plagioclase crystals are often broken. There are also several well-formed crystals of a mineral with the characters of a pyroxene, pale brown and slightly pleochroic, with an extinction angle as high as 45° (cf. Nos. 62 and 64). The structure of the rock is clearly pyroclastic.

Conclusion.

Owing to the small amount of material at my disposal it is not possible to draw any very definite conclusions as to the character of these rocks. On the whole there is a considerable family likeness between the different types, and they seem to form a series of pyroxene andesites and rather basic pitchstones. The rock from Huka Falls is more acid and probably of rhyolitic composition. In many cases it is possible to distinguish a more or less distinct fragmental structure, and some are tuffs, or at any rate a mixture of lava and tuff.

The general mineralogical composition suggests that they belong to the subalkaline family, and they contain pyroxenes of a rather unusual type.

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[1] See Hector's map.

IV.—THE RECENT GEOLOGICAL HISTORY OF THE BALTIC. PART III: THE WESTERN PART OF THE SEA, THE SOUND, AND THE BELTS.

By Sir H. H. HOWORTH, F.R.S., F.G.S.

IN two previous papers I have set out the conclusions generally held by Northern geologists in regard to the more recent history of the Eastern Baltic, according to which it was once a great enclosed fresh-water lake or sea, the *Ancylus* lake, which by the breach in the land-bridge connecting Skäne and Denmark was converted into a brackish-water sea, the *Litorina* sea, which has in turn become less and less saline until it has reached its present condition.

In the second of these papers I quoted a number of facts proving the breach just mentioned. Before I turn to another chapter of the interesting history, I propose to add to these facts, and to show more conclusively that the whole coast of the Southern Baltic is an area of depression where evidences of the subsidence of the land in recent times are general and consistent, and where, so far as we know, this subsidence while in progress was not qualified by any partial or intermittent upheaval. I shall quote some additional facts in this behalf from Hahn's memoir entitled "Untersuchungen ueber das Aufsteigen und Sinken der Küsten" (Leipzig, 1879). He first quotes the observations of Berendt that in the delta of the Niemen the land has sunk so much and become so marshy that where, as is attested by Church-records, as late as 1576 forests of oak grew, no such trees will now grow because of the wet nature of the ground. He also quotes numerous cases of sunken peat bogs, attesting the same fact. Thus, west of Labiau there are found at a depth of 3·1 metres remains of a submarine forest with pieces of coal among the trees, and near Schwarzort in the Kurische-Nehrung at a depth of 6·2 metres have been found ornaments of amber, showing that a considerable subsidence has taken place in the human period.

An old stone sea-wall at Fielenhof on the so-called Windenburger Ecke, which is not more than 110 to 115 years old and which was erected to protect a garden against the sea, is now overflowed. A lawsuit between the fiscal authorities and the inhabitants has shown that some islands covered with reeds and rushes in the haven were not long ago parts of the mainland, and were not detached by a gradual process of eating away, but by a rapid overwhelming by the water.

In the Kurische-haff the water has so encroached that the distance between it and the so-called 'Grossen Friedrichsgraben' has greatly diminished. The foundations of the old Kurhaus of Cranz are now under the sea, and the land there is said to lose 1·89 metres a year—this, be it remarked, in an enclosed bay where there is no tide. Rugen and the small islands round it have become considerably smaller in late years.

Submerged forests occur along the coast of Pomerania, near Köslin, between Rator and Lieps, in Rugen at Lindenhaken, and the Lobber Schaar (the Monks estate). The Mecklenburg coast, as far as Wismar and beyond, is broken by a number of inlets, apparently due to subsidence. At Travemünde are two great blocks of stone which are now in the water, but which the sea had not reached at the end of the eighteenth century. At Heiligenhaf and the island of Fehmarn we again meet with submerged forests, and at the eastern outlet of the Fehmarn Sound are remains of an ancient wall. The whole coast of Schleswig-Holstein bears similar traces, *inter alia* the worn island of Werder, near Heiligenhaf. The former perch-frequenting inland lake on the coast at Probstei is no longer a lake, but an arm of the sea. The ancient hunting lodge of Bramhorst on the same coast has disappeared, while the trunks of the trees in the wood which once surrounded it are now submerged as far out as five hundred paces from the shore. The castle of Altbulk on the north side of the harbour of Kiel did not when it was built stand as it does now, on the edge of the water. The Wurdebye Noer, near Eckenförde, has all the appearance of having formerly been a lake. It is now an arm of the sea. According to V. Maack the remains of the Schleimunder Burg at the mouth of the Schlei are now under water. The island of Oehe, north of the mouth of the Schlei, was formerly a peninsula, and the peninsula of Maasholm on the south side of the same is rapidly becoming an island. V. Maack calls attention to the haven of Dywig or Ducwig on the north-west coast of Alsen (near Norburg), which was once a lake. The Slipsee and the Bankeldam, between Apenrade and Hadersleben, are examples of the same kind, as is the inlet of Heilsmunde on the Danish frontier (op. cit., pp. 162–165).

Örsted, in his monograph on the fauna of the Sound, to be presently referred to, speaks of submergences having taken place at Vedbœk, between Sletten and Humlebœk, and at Sledkersteen, both on the coast of Zealand, attested by the reports of fishermen who had noticed trunks of trees with their roots in the ground in the sea far from the shore (op. cit., p. 18).

K. Rördam, in his memoir entitled "Salt vandsalluviet i det nordostlige Sjaelland," has shown in a map the large area which was depressed in that part of Denmark in recent times, especially in so far as the depression affected its great fiords, notably the Isefiord and the Roskildefiord, and the two once submerged bogs known as the Store and Lille Törvegrund, south of Frederiksvaerk; and he mentions how in the Sound at Charlottenlund, opposite the restaurant of Constantia, there is a submarine turbary two metres under the water.

He also describes several peat bogs now above sea-level, but underlying beds of the *Litorina* time, on the coast of Zealand, as proving the same fact. Thus, in a turf bed a quarter of a mile north of Skuldelev, called Mosejord, there is a bed of clay 2·5 feet thick, containing *Cardium edule* and *Nassa reticulata*, overlying one of turf with remains of oak, birch, juniper-berries, and fruit of the buck bean. Another peat bog at Herslev shows a bed of meadow-soil covering marl, without shells, then a layer with many beach shells, lastly a bed of the same kind of turf as that at Skuldelev.

At Nivaafiord, the innermost part of Esromfiord, the fiord of Raageleje, the Ramlösifiord, and the Nörremose, near Kregome, and in many spots in the old fiords of Skuldelev and Selsö, similar phenomena have been forthcoming as the result of excavations and borings. Thus, at Hovenge, 2,800 feet south-east of Brandbjerggaard in Selsö Sogn, V. Madsen reports a section consisting, in descending order, of mould, turf, fresh-water loams with fresh-water shells, and then a bed with salt-water fauna, comprising *Tapes aureus*, *T. pullastra*, *Cardium exiguum*, and *Rissoa inconspicua*, also containing leaves of oak, willow, and hazel-nuts, then gravel, then turf again.

At Hovenge, 1,200 feet south-west of St. Olaf's Church in Selsö Sogn, a *Cardium* mud with many salt-water mollusca overlies peat with remnants of the fir-tree. Eight hundred feet north-east of Buskbjerg in Skuldelev Sogn is a deposit of mould overlying *Cardium* mud with *Ostrea edulis*, *Scrobicularia piperata*, *Cerithium reticulatum*, *Rissoa membranacea*, *Litorina rudis*, *L. obtusata*, which again overlies turf with remnants of the fir. Eighteen hundred feet east of Östby in Selsö Sogn is a sandy turf, then marine sand underlaid by clayey sand, and this by *Cardium* mud with *Nassa reticulata*, *Litorina litorea*, *rudis* var. *tenebrosa*, and *Scrobicularia piperata*, and this again by a great peat bog with *Corylus avellana* and *Betula odorata* (op. cit., pp. 126–128).

As evidences of the former sinking of the land in North Jutland, which was then followed by a rise, are the two so-called wild moors. The smaller one is south of the eastern outlet of the Lim Fiord and the larger one north of Aalborg. The springs in the neighbourhood of the latter were in Forchhammer's time still brackish or saline.

When we cross over into Skäne similar evidences of beds of recent marine shells, now several feet above high-water mark and lying upon beds of a subaerial type consisting of turf with fresh-water and land shells, abound. I referred in my previous paper to the notorious instance of the so-called Jära wall, in which this phenomenon is conspicuous.

Again, about a mile south of Helsingborg there is a bed 500 feet broad lying along the coast, and bounded on the land side by a steep slope of from 30 to 40 feet high. This steep slope is formed of fine limey laminated sand, arranged horizontally and nearly a foot in depth, which is overlaid by a definite layer of grey clay. A few shell fragments have been found in the clay.

The bed which lies between this slope and the sea is formed of several layers, the uppermost of which, 3–3·5 feet in depth, is formed of sandy gravel which the Swedes call 'strandgrus.' The gravel consists partly of angular and partly of rolled dissimilar rocks, among which are a large number made up of chalk and flint, together with frequent whole and broken shells of *Cardium* and *Mytilus*. This can be no other than the representative of the *Litorina* beds, and below it we find in due position the representative of a subaerial bed of turf. Next we have a bed 1·5 feet thick of yellow-grey loam containing abundant fresh-water shells, among which the following have been collected: *Planorbis complanatus, Bythinia tentaculata, Limnæa limosa, L. ovata-normalis, Valvata cristata, V. piscinalis*, and an *Anodonta*. Below this, again, is a bed of turf a foot thick, containing partly branches and partly stumps of oak-trees (Erdmann, Geol. För. i Stock. Förh., i, p. 93, etc.).

Erdmann, in the second volume of the Geol. För. i Stock. Förh., gives several other instances of beds in the neighbourhood of Malmö and Lund, notably at Hildesborg (a mile from Landskrona), at Bjerred (a mile west of Lund), and at Barsebäck (1½ miles south-east of Landskrona), where in sections, several feet thick, layers of marine sand and gravel occur, containing fragments of dwarfed forms of *Cardium* and *Mya* with thin shells, and lying on terrestrial deposits several feet above the present Sound (vide op. cit., vol. ii, pp. 97, 98, etc., etc.), all concurring to the same conclusion — that a recent submergence along all this coast has been followed by a recent upheaval.

Another remarkable evidence of the submergence we are discussing is afforded by the Zealand river Nivaa, now a small stream, but whose former course, says Rördam, can be traced at least for a distance of 3 kilometres beyond the borders of the Sound, which shows that here the ground had sunk to the extent at least of 8 metres, while on the opposite side of the Sound De Geer calculated that it had once sunk 15·5 metres (Rördam, op. cit., p. 131).

It is perfectly plain from this unanimous and most consistent geological testimony that there has been a great and notable and recent breakdown and submergence in various parts of the area now occupied by the Danish archipelago, where it is claimed the land-bridge recently existed which cut off the connection of the North Sea with the Baltic.

The breach in this connection, as we have seen, greatly affected the hydrographical character of the Eastern Baltic, and especially affected its molluscan and other fauna by converting what was previously a fresh-water lake into a brackish sea. In pursuing this induction in the previous papers, I limited my examination of the lessons taught by the Baltic fauna to those presented by its eastern section and to that portion of the sea lying to the east of the longitude of the island of Bornholm. I now propose to examine in some detail the fauna of the Western Baltic and its three great waterways, and to collect some scattered facts which may be useful to others besides geologists, and which greatly strengthen the case, especially on its chronological side.

I propose to begin with a conspectus or general balance-sheet of the living molluscan life in the Southern Baltic, and to show its accretion as we move westwards. According to Middendorf (Bull. phys. Math. St. Petersb., 1850, viii, p. 65) and A. Hensche (Schrift. Phys. Oec. Gesch. Königsberg, 1861, p. 90), there are only six marine shells in the eastern section of the Baltic: *Hydrobia balthica* (*Rissoa ulvæ* ?), *Neritina fluviatilis, Mytilus edulis, Mya arenaria, Tellina* solidula, and *Cardium edule*. Of other marine invertebrates from thence we also have *Medusa aurita, Cyanea capillata, Gammarus*, and *Idotea entomon.*

Let us now move westward. A good test of the poverty of the Baltic in marine life in the longitude of Bornholm is afforded by the following list of the result of a fortnight's careful dredging on both the east and west of the island by a collector employed by Meyer named George Holm, in 1863, and containing a list *of all animal forms*, living or dead, he came across while dredging, except fishes and Protozoa. (See Mey. & Möb., "Fauna der Kieler Bucht," i, xx.)

Succinea oblonga.
Neritina fluviatilis.
Rissoa ulvæ.
Pontolimax capitatus.
Litorina litorea.
Mytilus edulis.
Cardium edule.
Tellina solidula.
Sarcochitum polyoum.
Piscicola sp.
Nereis diversicolor.
Spirorbis nautiloides.
Planaria torva.
Dendrocœlum lacteum.
Palæmon squilla.
Crangon vulgaris.
Mysis flexuosa.
Gammarus locusta.
Idotea tricuspidata.
Sphæroma sp.
Jæra sp.
Larvæ of *Phryganea*, and three different kinds of *Diptera.*

The shells reported from the sea between Moen, Stevns, the south coast of Skäne, Bornholm, and Rugen are :—

Utriculus obtusus.
Hydrobia ulvæ.
Litorina rudis.
Astarte borealis (? *elliptica*).
A. compressa.
Mya arenaria.
Macoma (*Tellina*) *calcarea.*
M. balthica.
Cardium exiguum (var.).
C. edule.
Mytilus edulis.

(Petersen, "Om de Skalbarende Mollusken udbredningsfolhold i de Danske haven, etc.," p. 42.)

According to Munthe, the two species of *Astarte* from this part of the Baltic, which he identifies as *A. borealis* and *A. elliptica*, are of diminutive growth, and live there therefore under unfavourable conditions. There cannot be any doubt, he adds, that they migrated to the Baltic after the *Ancylus* time (Bull. Geol. Inst. Ups., ii, pp. 14, 15). *Litorina litorea*, according to Munthe, also occurs in the Rugen waters, while *Scrobicularia piperata* and *alba* are reported from the mainland opposite Rugen at Greifswald. K. Brandt says that to the east of Rugen there are no sponges or Tunicates, only one Bryozoan, namely, *Membranipora pilosa* (var. *membranacea*), and one Cirripede, i.e. *Balanus improvisus.*

The straits between Gjedserode, in the island of Falster, and Darsserort, on the mainland of Mecklenburg, seem to form a considerable barrier to the eastern migration of submarine forms, and west of the straits the life becomes decidedly richer.

In 1889 Dr. Max Braun published a paper on the fauna, except the Polyzoa, of Wismar harbour in the Archiv Nat. Hist. Soc. Mecklenburg. In this he gives, *inter alia*, a list of the mollusca which had been found there, as follows :—

Lamellibranchiata.

Mytilus edulis.
Modiolaria discors.
Cardium edule.
C. exiguum.
C. fasciatum.
Astarte borealis.
Tellina balthica.
Scrobicularia piperata.
Mya arenaria.

Opisthobranchia.

Odontostoma rissoides.

Prosobranchiata.

Litorina litorea.
L. obtusata.
L. rudis.
Lacuna divaricata.
L. pallidula.
Rissoa octona.
Rissoa membranacea.
R. cornea.
R. parva.
Hydrobia ventrosa.
Neritina fluviatilis.

A much richer fauna occurs on the western seaboard of Mecklenburg. Thus, Dr. Heinrich Lenz contributed a memoir on the mollusca of the Travemünde or Lubeck Sound, to the great collection of materials published by the Commission of the German Government on the Baltic, from which I take the following list of molluscs (op. cit., iv, p. 170):—

Mytilus edulis.
Modiolaria discors.
Montacuta bidentata.
Cardium edule.
C. fasciatum.
Astarte borealis.
A. sulcata.
Cyprina islandica.
Tellina balthica.
Scrobicularia piperata.
S. alba.
Solen pellucidus.
Corbula gibba.
Mya arenaria.
Saxicava rugosa.
Pholas candida.
Teredo navalis.
Æolis Drummondi.
Æ. rufobranchialis.
Polycera ocellata.
Doris pilosa.
Doris proxima.
D. muricata.
Utriculus obtusus.
U. truncatulus.
Odostomia rissoides.
Litorina litorea.
L. obtusata.
L. rudis.
Lacuna divaricata.
L. pallidula.
Rissoa inconspicua.
R. membranacea.
R. octona.
Hydrobia ulvæ.
H. ventrosa.
Cerithium reticulatum.
Buccinum undatum.
Nassa reticulata.
Fusus antiquus.
Neritina fluviatilis.
Loligo breviceps.

Braun makes a general comparison between the marine fauna of Wismar and of the Lubeck inlet, which is interesting as showing how local conditions determine problems of distribution, even under such similar surroundings. Thus, he says, 31 species of marine animals occur at Wismar which are not found in the Lubeck gulf, namely: *Podocoryne carnea*, *Sagitta germanica*, all the Rotatoria, *Polynoe squamata*, *Valkeria cuscuta*, *Dias discaudatus* and seven other Copepods, *Podon minutus*, three Ostracods, three forms of Amphipods; and among the molluscs, *Cardium exiguum*, *Odontostoma rissoides*, *Rissoa cornea* and *parva*; and lastly, *Oikopleura flabellum*. These are chiefly small pelagic forms, some of which were naturally overlooked by Lenz.

On the other hand, there are wanting many forms at Wismar, found by Lenz at Travemünde. He mentions 137 species from Lubeck, while there are only 101 at Wismar. Only 70 species are common to both places, and 67 are peculiar to the Lubeck district, namely:—

Sponges	2
Cœlenterata	7
Echinodermata	1
Vermes	17
Bryozoa	2
Crustacea	12
Mollusca	24
Tunicata	2
	—67

Most of these, Braun holds, have their furthest eastern limit in the Travemünde or Lubeck district, while Wismar itself seems to be the furthest eastern limit of many others.

(*To be concluded in our next Number.*)

REVIEWS.

I.—The Geology of South Africa. By F. H. Hatch and G. S. Corstorphine. 8vo; pp. 348 and xiv. (London: Macmillan & Co., 1905. Price 21s. net.)

THE discovery of gold and diamonds in the Transvaal has been the parent of many literary prodigies, some great, some small, but mostly of the mouse-like kind. Among the latter, papers on the origin of gold in the banket, the extension of the main reef, and countless pamphlets on the geology of the Transvaal form a conspicuous feature.

The authors of the present work attempt to collect into a small compass the varied sources of information relating to the geology of the Transvaal, and to a less degree that of South Africa as a whole. Those acquainted with the literature of the subject will admit that they have succeeded in producing a clever abstract of a most bewildering subject. Those fresh to the enquiry will be spared the trouble of digesting much dead matter, or if they desire to do so they may consult the bibliography given at the end of the volume.

Reviewing the book as a whole, its prominent feature lies in the small space into which the authors have skilfully compressed most of the essential problems dealing with the geology of a vast tract of country. One is horrified to think how many volumes a studious German might have filled and yet not have advanced our knowledge of the subject any further, if so far. Several years' practical acquaintance with the geology of South Africa has enabled the authors to avoid the pitfall of voluminosity. They have, perhaps, not altogether escaped the unaccountable mesmerism that diamantiferous deposits seem to exercise on the skilled and unskilled mind. On the other hand, important dynamical and physical problems are almost entirely ignored, at which the scientific man will lament, but the practical man rejoice.

The book is divided into three parts. Part i deals with the Pre-Karroo rocks. Owing to the want in similarity of the succession in different areas this portion has been divided into two sections. Section 1 describes the Pre-Karroo rocks of Southern Cape Colony, a subject already and more fully treated of by Mr. A. W. Rogers. It, however, forms a suitable and necessary introduction to Section 2, which gives an excellent and clear account of the Pre-Karroo rocks of the Transvaal, together with brief descriptions of these rocks in the remaining portions of South Africa. The advance made in determining the puzzling stratigraphical sequence of several unconformable and unfossiliferous formations will be gathered from a comparison of the authors' conclusions with the latest published results (1904) of Dr. Molengraaff. The origin of the gold in the banket is seriously discussed. The authors adopt the theory of subsequent infiltration.

The Karroo and Post-Karroo rocks receive sufficient attention in parts ii and iii. Part iv, describing the volcanic rocks of doubtful origin, contains a chapter of 29 pages on the diamond-bearing deposits.

The correlation of the various rock groups in part v deserves the closest attention. This difficult question is clearly and philosophically placed before the reader, who can gather in brief what permanent results have been obtained and in what direction future work lies. We may state that this portion could only have been written by one intimately acquainted with the recent results obtained in Cape Colony, and shows the value of the work accomplished by the surveyors in those regions.

In the way of print and illustrations of fossils and rock scenery nothing remains to be desired. Two excellent geological maps, printed in colour, afford the reader the means of following the authors' descriptions of the different regions. The introduction of various tints of black and grey for the Karroo deposits does not seem a happy one. Since the Karroo beds range from the Carboniferous to the Jurassic it is scientifically incorrect; while experience in this country has proved such colours to be artistically hopeless. We trust they will not receive official sanction. W. G.

II.—NINTH ANNUAL REPORT OF THE GEOLOGICAL COMMISSION OF THE COLONY OF THE CAPE OF GOOD HOPE, 1904.

THIS report contains a full account of the progress made during the year 1904. In completeness of detail, and in the number of the accompanying illustrations and maps, it should be classed as a memoir rather than as a report.

In the Chairman's letter, and in the introduction by the Director, it is stated that the work of the Survey was hampered by lack of funds, so that important districts could not be visited owing to the cost of hired transport. Throughout the present report we read how the welfare of the colony largely depends on the water supply obtained from wells and borings. It therefore seems surprising that this useful survey of the rock formations is not being pushed on irrespective of cost. Engineers visiting South Africa have acknowledged the value of the work accomplished by the Commission, and the present report shows that the officers of the staff pay especial attention to this all-important subject. Surely the most 'practical' of men cannot fail to see the necessity of knowing the order of succession, distribution, and structure of the rock formations, for on these the success or failure of boring for water, as well as the search for minerals, essentially depends. Let us hope that the Commission will be afforded greater facilities for continuing their work on the same sure grounds with which it has been and is being conducted.

In the present report a useful, if somewhat brief, summary by the Director, Mr. A. W. Rogers, precedes the detailed account of the areas examined. A table of strata of the succession in Cape Colony, with their probable European equivalents, is here given, but without comment. We note, however, that the table is to be regarded as that used at present by the Survey. Evidently, then, alterations and additions may be expected as the field-work proceeds.

The detailed portion of the report includes a description of the geology of the north-western part of Van Rhyn's Dorp by the Director. The discovery of another set of rocks, termed the Nieuwerust Series, shows how much remains to be done before South African stratigraphy is reduced to something like order. This series, consisting of arkose, quartzite, and slate, is regarded as later in age than the Malmesbury Beds, granite, and the Ibiquas Series.

The descriptive account of the geology of Long Kloof, by E. H. L. Schwarz, shows that here we are dealing with a highly folded region, as to the nature of which Mr. Schwarz offers some interesting suggestions.

Mr. A. L. du Toit presents a very detailed and interesting account of the geology of Aliwal North, Herschel, Barkly East, and part of Wodehouse. Considerable additions are made to our knowledge of the Karroo Series. Mr. Du Toit finds it possible, on palæontological evidence, to divide the great thickness of the Beaufort Series into two portions. For the upper portion he proposes the name "Burghersdorp Beds." Besides being characterized by a special reptilian fauna, they are further interesting from the occurrence of *Glossopteris* and Lepidodendroid stems in association with *Thinnfeldia*. In the account of the volcanic beds of the Stormberg Series, descriptions are given of over sixty volcanoes occurring in Wodehouse, Barkly East, and Herschel; while descriptions of others in Aliwal North are promised. This evidence of powerful vulcanicity is unique in the Jurassic period of the earth's history.

A special feature of the report consists in the welcome addition of numerous black and white maps illustrating the areas described. The want of headlines, a fuller table of list of contents, and a more copious index will be felt by the general reader. Some of the figures, too, are without accompanying scales, and the frequent inclusion of their descriptive indices in the text becomes exasperating.

These are, however, minor faults, easily capable of remedy, but detailed perfection cannot be expected from a small and sadly hampered staff. We must be content with the evident skill and honesty of purpose which has marked the work of the Commission during the year included in this report and in those preceding.

W. G.

MEMOIRS OF THE GEOLOGICAL SURVEY OF ENGLAND AND WALES.

III.—THE GEOLOGY OF THE COUNTRY BETWEEN DERBY, BURTON-ON-TRENT, ASHBY-DE-LA-ZOUCH, AND LOUGHBOROUGH (EXPLANATION OF SHEET 141). By C. E. FOX-STRANGWAYS, F.G.S., with a Chapter on Charnwood Forest by Professor W. W. WATTS, M.A., M.Sc., F.R.S. 8vo; pp. 83. (London, 1905: E. Stanford, 12, 13, and 14, Long Acre. Price 2s.)

THE area described in this memoir contains a number of small inliers of pre-Cambrian rocks belonging to the Charnwood Forest complex, which are dealt with by Professor W. W. Watts, who described the pre-Cambrian of Charnwood Forest in the memoir dealing with the region to the south (155).

The next formation in the succession is the Carboniferous Limestone, represented by a few inliers situated on a continuation of the Charnian axis. Although covering only a small area this rock has yielded a large number of fossils, and a list of over a hundred species identified by Dr. F. L. Kitchin is given. Above the limestone are the limestone shales seen at Ticknall, Dimminsdale, and Calke. They have thinned out from 5,000 feet in Derbyshire to some 600 feet at Breedon, and are probably still less on the flanks of Charnwood. The Millstone Grit above has been divided into three divisions, which are, however, not very persistent. There is a general diminution in the coarseness of the grains from below upwards, the lower beds being generally conglomeratic, the middle grits, and the upper fine-grained thin-bedded sandstones. The formation contains a plentiful supply of good water, now utilised by Melbourne, Castle Donington, Long Eaton, and other places.

Much of the detailed information relating to the Coal-measures is reserved for a memoir on the Leicestershire Coalfield. There are here given, however, two tables showing the thickness of the seams and the intervening measures.

Certain purple marls and breccias with a little sandstone, coming between the Carboniferous and the Trias, are doubtfully referred to the Permian (as in the old memoir) in the absence of evidence to the contrary.

The Bunter occurs only as pebble-beds in this area, the Lower Soft and Upper Soft Sandstones being either absent or represented by pebble-beds. They are well exposed round the west and north sides of the coalfield, overlapping the beds called Permian, but are not very thick. They are better developed further north, between Bretby and Foremark, where they form the sides of the valleys. The Bunter is followed by the Lower Keuper sandstone and marls, from about 50 to 100 feet thick, thinning towards the north. Beds of breccia occur at the base, well seen at Castle Donington. A considerable area is covered by these beds to the south of the Trent. Between Griffydam and the Charnwood Hills the basal breccia becomes much more developed, replacing a great deal of the sandstone. It rests here on Coal-measures, and is unaffected by a large fault below. The Keuper marls, which come next, occupy a larger area than any other formation, covering three-fourths of the map. As a general rule they pass down into the sandstones below, but overlap them in the neighbourhood of the old land surface of the Charnwood Hills. They are lithologically red and grey marls, with thin unimportant bands of white sandstone, only one, south of Castle Donington, being worth mapping. The marls contain beds of gypsum worked at Chellaston and Gotham.

Three patches of Lias, with narrow outcrops of Rhætic at their bases, occur. The one at Normanton is a spur of the main mass of Lias in the next sheet to the east; the other two, at Gotham and West Leake, are outliers. The Rhætic consist of about 20 feet of dark laminated shales resting on tea-green marl. Above is grey shale with thin limestones passing up into Lias. A collection of fossils from the Normanton tunnel has been described by Mr. Montagu Browne.

The Drift is much thinner and less important than in the sheet to the south. It is found to cap the hills, except in the Charnwood district, which stands at a higher level.

The oldest post-Glacial deposit is the high-level valley gravel flanking the Trent and Derwent Valleys on the northern side, and it forms a sort of passage from Glacial to Recent times. River terraces border all the main rivers at about a height of 15 to 20 feet above the alluvium, from which they usually rise in a sharp bank. They become mingled with modern alluvial deposits where tributary streams enter. *Hippopotamus*, *Elephas*, *Rhinoceros*, and *Bison* are recorded from them. For the most part, contemporaneous with the terraces are lacustrine deposits lying in hollows in the Keuper marl; Sinfin Moor is the best example. Alluvium covers a considerable area in this district owing to several important streams running into the Trent here. It is 20 to 30 feet thick.

The last chapter is devoted to a description of the faults, and is followed by an Appendix of 30 pages of Borings and Pit Sections. An Index concludes the work. There are a number of figures in the text and a fine plate of High Sharpley, Charnwood Forest.

REPORTS AND PROCEEDINGS.

I.—BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE. CAPE TOWN, SOUTH AFRICA, AUGUST 16TH, 1905.

ADDRESS TO THE GEOLOGICAL SECTION (C) BY Professor H. A. MIERS, M.A., D.Sc., F.R.S., President of the Section.

IN opening the proceedings of Section C on its first visit to South Africa, and speaking first on behalf of those who are visitors, I think I may justly claim that to no Section of the British

Association can this visit be more interesting or even more exciting than to us; we enter for the first time a country whose geological features and history, and whose mineral productions, have long aroused the keenest interest among European geologists and mineralogists.

We have followed the discoveries and discussions of South African writers; we have read your views and have become familiar with your terminology; we have heard the reports of those who have visited the country, either as travellers or with the special object of investigating its geological problems or mineral resources; and, indeed, ever since the Geological Society of London received the historic papers of Andrew Geddes Bain, the father of South African geology, many of the memoirs of your own geologists have been communicated to European societies and journals; we have looked from afar with yearning eyes upon this alluring country; and at length we have found ourselves upon its shores.

It has not been given to many of us to see those great pioneers of South African geology whose work was done in the days before amateurs and experts could come out for a few weeks or months to take a hurried survey of the country; but their enduring labours, which have laid the foundation of all subsequent work, are well known to us, and it is not necessary for me to do more than mention the familiar names of Bain, Wyley, Stow, Atherstone, Sutherland, and Dunn. Of these only the last-named survives; but when one remembers that his maps of North Cape Colony and of Orange River Colony have served as the basis of the maps now in use, one is reminded how recent is the whole history of South African geology, and how much was achieved in so short a time by these early workers.

It is exactly one hundred years since John Barrow wrote the concluding words of his "Travels in South Africa" which first directed attention to the geology of this country; it is only fifty years since Bain sent home the manuscript of the classic papers to which I have already alluded.

Since their days many have been the scientific visitors to the country who have remained here for longer or shorter periods, whose works have made us familiar with its problems and have contributed to their solution; the names of Cohen, Draper, Exton, Gibson, Green, Griesbach, Passarge, Rubidge, Sawyer, Schenck, and Seeley recall some of the most substantial scientific work which has been done either by visitors or residents. Several others who, without visiting the country, have by their researches in Europe helped to unravel the problem of South African stratigraphy were enumerated by Dr. Corstorphine in his interesting and exhaustive Presidential Address last year.

If we must regret that we never had the opportunity of seeing the great pioneers and the earlier workers, we may rejoice that we have been able to meet those who are now actively engaged in continuing their labours; the period of cursory visits and fragmentary essays is closing, and the era of deliberate and systematic surveys is beginning; we now look for authoritative information to the Cape Survey inaugurated by Dr. Corstorphine in 1895 and so ably continued by his successor Mr. Rogers; to the Transvaal Survey begun by Dr. Molengraaff in 1897 and auspiciously revived under Mr. Kynaston; and to the Natal Survey which Mr. Anderson has so successfully directed since 1901. I hope that it will not be long before there is no part of South Africa outside the direct supervision of a systematic and well-ordered survey.

There is perhaps some danger lest in a developing country, where the commercial possibilities are prominently before all eyes, the immense importance of such surveys should be overlooked, and lest it should be thought that what appears to be purely scientific research may be left to take care of itself until the mineral wealth of the country has been explored. I cannot enter too emphatic a protest against such a view; how closely the two interests are knit together must be apparent to anyone who reflects that the nature and sequence of the more northerly formations which have yielded coal, diamonds, gold, and metalliferous deposits can only be studied in the light of the more intelligible geology of Cape Colony and Natal. It is, moreover, immensely to the advantage of South Africa that you have intimately connected with the mining industry geologists of such training as Doctors Corstorphine, Molengraaff, and Hatch, who have all gained valuable experience upon geological surveys.

I may now, perhaps, cease to speak merely as a representative of the visitors and identify myself more closely with the Section as a whole; for the most gratifying feature of this meeting is that it is not merely a visit of strangers who are enjoying your hospitality, but that with Section C of the British Association is fused Section B of the South African Association, so that for the time being we are all colleagues; and even such vexed questions as the correlation of the rocks of the Transvaal or of Rhodesia with those of the Cape, or the origin of Banket, or of Blue Ground, or the extension of the Main Reef Series (perhaps it is no longer necessary to include the problem of the Dwyka conglomerate) can be discussed by us on the spot as members of the same body inspired by the same earnest desire for truth.

I began these preliminary remarks by asking that I might be regarded as the spokesman of the visitors, and therefore represented myself as a geologist visiting the country for the first time. I must, however, make a frank confession. Not only is this my second visit to the country, but I have not even any claim to be called a geologist. My training and experience have been such that upon many of the questions which must be most interesting to this Section I am not competent to form an opinion or to appreciate properly the evidence. I must, therefore, crave your indulgence if in this Address I refrain from discussing any of the problems of surpassing interest which naturally engage the attention of those who are occupied with the study of South African geology. It would indeed be an impertinence for me to do so.

I venture, however, to hope that the frontier between geology and mineralogy is so ill-defined—if indeed a scientific frontier can be said to exist—that the thoughts and occupations of one who has confined himself to the study of minerals, and that rather in the laboratory than in the field, are not alien to the interests of Section C.

Experimental Geology.

A somewhat lamentable aspect of modern science is the vast array of unorganised facts which are awaiting co-ordination; this is too often because they have been amassed without any definite idea of the purpose which they may serve; consequently it may happen that laborious observations belonging to one science may fail to attract the regard of a neighbouring science merely for want of the mutual acquaintance which would make them serviceable to each other; and in these days of exclusive specialisation the introduction which might lead to a happy union is, perhaps, not brought about for years. None can be more fully alive to the importance of such an alliance than those whose work lies on the borderland between different sciences; the mineralogist, for example, is in contact on the one side with the experimental sciences of chemistry and physics, and on the other with geology, which has scarcely yet entered the experimental stage. He cannot fail to be impressed by the need of the appeal to experiment on the geological side of the border, and it is perhaps his duty to supply the want as far as lies in his power.

Owing to this very need some of the most difficult problems in geology are those concerned with the origin of minerals and of the rocks which they compose. One need but recall the many theories which have been held about the origin of mineral deposits, the filling of metalliferous veins, the local concentration of certain minerals, the distribution of various rock types, the existence of rock magmas of diverse compositions, and the differentiation of their constituents. Could the importance and difficulty of such problems be better illustrated than in South Africa, and by its two most valuable minerals, gold and diamond?

Now all these are problems in which direct appeal may, and indeed must, be made to laboratory experiments; the well-defined minerals of which the earth's crust consists do not, after all, number much more than 800, and of these many have already been manufactured in the laboratory. Speculation upon the origin of rocks and minerals should surely be controlled by the results of experiments, and equally should experiment which is to be of service to geology be guided by a knowledge of the problems to which it is to be applied. It will be my object in the present Address to illustrate these principles by examples drawn from recent experimental work which can be applied to geological problems, and to indicate the course which such research is likely to pursue in the immediate future.

It seems to be sometimes expected of a Presidential Address that it should contain a summary of the progress of a science during past years, and this is no doubt very useful and instructive; but if we are to go forward in our scientific work we must not be satisfied with the patient accumulation of details, or content to congratulate ourselves upon the number of them which have been amassed. I venture to think that it is more profitable to take our stand upon the actual work of to-day, and from that tower of observation to look forward to the future rather than backwards to the past; to exclaim with the poet—

> "No, at noonday in the bustle of man's work-time
> Greet the unseen with a cheer!
> Bid him forward."

It would be interesting enough to trace the history of the artificial reproduction of minerals, beginning with the famous experiment of James Hall; to follow the lines that led to the development of the French School during the last half of the nineteenth century; to dwell on the researches of Senarmont, Ebelmen, Daubrée, and Sainte-Claire Deville; to show how the increasing study of petrography and the invention of the electric furnace have led to renewed activity in the attempts to reproduce igneous rocks and the rock-forming minerals; to discuss the more modern experiments of Fouqué and Lévy, Lagorio, Loevinson-Lessing, and Morozewicz; or to describe the manufacture of many an interesting mineral by de Schulten and others who are actively prosecuting research of this nature, including such sensational achievements as the production of the ruby by Frémy and of the diamond by Moissan.

Instead, however, of attempting a survey of all that has been done, or even of all that is being done in the artificial reproduction of minerals, let me adhere to the principle that I have laid down, and discuss only a few of those researches, now being carried on, which promise to be most fruitful because their methods and aims are inspired by the discoveries and views of modern chemistry and modern physics.

Van 't Hoff's Work on the Salt Deposits.

Among such researches the most remarkable are those conducted by Professor van 't Hoff and his pupils during the last eight years upon the Stassfurt salt deposits. These deposits are of enormous extent, more than 1,000 feet thick, and consist of fairly well-defined layers of various sulphates and chlorides of sodium, magnesium, and potassium, and their double salts and hydrates. It has long been supposed that the minerals have been derived from the evaporation of sea-water which contains in solution the chlorides of sodium, magnesium, and potassium, with sulphate of magnesium and small quantities of calcium salts; and the general sequence of the minerals is that of their solubility; the less soluble sodium chloride crystallised out first and is at the bottom, while the very soluble magnesium chlorides, having been the last to crystallise, occupy the top of the series. But the problem is by no means so simple as to be one of mere solubility in water; the rock salt itself persists through the whole series, and some of the associations are difficult to explain.

As is well known, the modern theories of solution mainly rest upon the behaviour of dilute solutions from which the principles of electrolytic dissociation have been deduced; but in the case of the concentrated solutions from which dissolved substances actually crystallise, very little is really known about the liquid itself. A great deal is known, however, about its equilibrium with the solids that separate from it, and the general laws of this equilibrium are expressed by the phase-rule deduced from mathematical considerations by Willard Gibbs, which states how many mechanically separable constituents can coexist under varying conditions of equilibrium in a system containing a definite number of chemical components.

A solution saturated with a given substance is one which is in equilibrium with that substance when the latter is in contact with it in the solid form; the phase-rule indicates the number of solids which must be in contact with a given solution; the only difficulty in practice is to determine the nature of the double salts or distinct hydrates that may be formed.

By means of a series of experiments upon the solubilities of these salts, either singly or in the presence of one another, in order to determine the composition of solutions saturated simultaneously with two or more substances, it is possible to obtain a graphic representation of all possible solutions containing the salts present in sea-water. From this the course of crystallisation of any particular solution, for example sea-water, can be predicted.

The general sequence thus theoretically predicted is as follows:—(1) Rock salt; (2) Rock salt with the magnesium sulphate, epsomite; (3) Rock salt with the double sulphate of potassium and magnesium, leonite; (4) Rock salt with leonite and the potassium chloride, kainite; (5) Rock salt, the magnesium sulphate kieserite, and the double chloride of potassium and magnesium, carnallite; (6) Rock salt, kieserite, carnallite, and the magnesium chloride, bischoffite. This last combination will persist until all the water is evaporated. This is found to be the general sequence, not only of the salts obtained on evaporating sea-water at 25°, but also of the Stassfurt deposits.

Up to this point the results have been summarised by Dr. E. F. Armstrong in a report presented to the British Association in 1901. Since that date the research has been prosecuted actively by van 't Hoff and his pupils, and now the conditions of equilibrium at 25° have been mapped out, not only for the above compounds, but also for the minerals thenardite, glaserite, astrakanite, and reichardtite, which occur in these deposits. The whole process of crystallisation of the solution, from which no fewer than twelve different salts have separated, can, therefore, be predicted, and their sequence and associations can be traced through numerous stages, beginning with the separation of rock salt and ending with a mixture of rock salt, kieserite, carnallite, and bischoffite.

In reconstructing the history of these deposits account must also be taken of the varying vapour pressures of the solutions which are saturated with the different compounds, as this really determines which particular compounds are stable, so that the matter is by no means so simple as might appear from this brief sketch. It is further necessary, in order to bring the process within reach of calculation, to assume that each deposit is removed from contact with the mother liquor after it has crystallised out; but fortunately this is practically what has happened in the Stassfurt deposits, for each layer is more or less separated from the succeeding one by an intervening layer of clayey material.

It may be possible even to go a stage further and obtain a clue to the actual temperatures that prevailed, for two minerals, langbeinite and löweite, are absent from the theoretical model made by van 't Hoff to represent what must happen during evaporation at 25°; and this indicates that while the deposits crystallised the temperature really rose higher than 25°, probably as high as 43°; in fact, after the conditions of equilibrium have been worked out, the appearance or disappearance of certain minerals can be used as a sort of geological thermometer, capable of indicating the limits within which the temperature can have varied.

The whole investigation is a splendid example of experimental research devoted to a particular problem and directed by a well-established theory; the chemist in his laboratory has now succeeded in tracing the changes that took place ages ago in the bed of a land-locked sea as it laid down its contents and finally became a dry basin, although he is not able to reproduce the original conditions or to work for the long periods which Nature had at her disposal. Without the logical consideration of the conditions necessary for equilibrium, countless experiments might be made upon these salts, and an immense amount of speculation might have been devoted to their possible reactions in the liquid state, about which we know so little, instead of to their equilibrium when solidifying, about which we know so much more.

Some Petrographical Problems.

The other geological problems which I have mentioned have also been beyond the reach of actual experiment, for it is hopeless to attain the immense pressures and high temperatures or the enormous time that may have been required for the growth of natural minerals in rocks and veins; and so when difficulties are encountered there is a tendency to 'explain' them (if the word may be so misused) by reference to the mysterious effect of conditions which cannot be brought directly within the reach of experiment.

I cannot help thinking that this has to some extent occurred in the discussion of the petrographical problems which I propose to consider next. There are two great liquid reservoirs from which minerals have crystallised—the sea, with its dissolved salts, and the subterranean baths of molten silicates, from which the igneous rocks have been derived. It is true that in the sea two of the constituents, water and sodium chloride, largely predominated over the others; but, after all, both sea and lava are liquids subject to the same physical and chemical laws.

An admirable summary of the evolution of petrographical ideas was given in the Presidential Address to the Geological Society of London in 1901 by Dr. Teall, who dealt both with the consolidation of rocks from molten magmas and their differentiation into species. It is not, therefore, necessary for me to consider anything but recent work which has been done during the last four years, and the earlier controversies may be left out of account.

Among the many problems relating to the mineral and chemical constitution of rocks which have yet to be solved, two, and those perhaps the most important, should lend themselves most readily to experimental treatment. The first is the problem of rock differentiation: why does a magma, even one which has presumably crystallised *in sitû*, separate itself into zones, or layers, or streaks of different constitution? And the second is the problem of mineral differentiation: why does a granite magma, for example, crystallise as a mixture of the particular minerals mica, felspar, and quartz, and why is the least fusible mineral the last to crystallise?

It will scarcely be possible for me to deal in this Address with more than the second of the two problems, but it will be apparent from the somewhat parallel case of the salt deposits that the mere order and manner of crystallisation of a mass of molten silicates must be a sufficiently complex problem to exhaust our attention for the present.

Magmatic Differentiation.

If we are to consider only recent experiments which have a bearing upon the problems of rock-magmas, it is not necessary to say much about the first great petrographical problem, that of the differentiation of magmas into various rock types; for in this connection very few experiments have been made, and practically none of recent date. Observations of the facts as they present themselves in the field accumulate every day; almost every important petrographical region is being studied with the particular object of determining the mutual relations of its rock-masses and the factors which have contributed to their differentiation. They have been ably discussed by Becke, Brögger, Becker, Cole, Harker, Iddings, Judd, Lacroix, Lévy, Pirsson, Rosenbusch, Teall, Washington, Zirkel, and many others; appeal has been made to the action of gravity, of temperature differences. of diffusion, of electric currents, of fractional crystallisation, of refusion, of chemically combined water, of absorption of the country rock; but with the exception of a single case, observed in the glassworks of Targowek, in which the top of a molten glass was found to contain less lime and more silica than the bottom, and some observations by Doelter upon boron-glass, there is scarcely a single experiment upon silicates which really bears directly on the question. That artificial glasses are far from homogeneous is known to glass-workers and to makers of lenses, but there is nothing comparable with the splitting of a magma into two or three distinct liquids which solidify as different rocks.

It is in the case of laccolites that the problem ought to present itself in the simplest form, for we may regard them as basins of igneous rock which have been practically imprisoned within solid walls and have crystallised *in situ*. There can, I think, be no doubt that differentiation has generally taken place even in such basins, that the margins have often a different mineralogical and chemical constitution from the more central portion, and that the differences are greater than can be accounted for by solution of the enclosing rock, and are often of a chemical nature which cannot be so explained.

The various theories that have been propounded fall into two distinct classes—those which seek the cause in the separation of solid material from the liquid, so that when the latter subsequently crystallised it constituted a different rock from the former; and those theories which assume that different liquids have separated from each other and then solidified as different rocks.

The first conception satisfactorily explains the manner in which the least soluble minerals are concentrated at the bottom or margin of an igneous mass, for they naturally crystallise first where the mass is coolest, or where contact with other crystals may have occurred; or even if they have been precipitated as a cloud throughout the magma they must be carried about by convection currents and ultimately sink together unless the magma be very viscous. Most geologists will probably agree with the conclusions of Vogt that some of the most important deposits of metal, metallic oxides, and sulphides have been produced by magmatic differentiation from deep-seated magmas which now constitute basic rocks associated with them. But this does not explain how the mass which has crystallised out may be not a mineral but a rock.

The actual observations on crystallising solutions do not amount to much; it is quite clear from laboratory experiments that crystals do grow by means of convection currents, which produce a flow of stronger solution towards the crystal and of weaker and warmer solution upwards and away from the crystal. The concentration currents can easily be seen in any ordinary aqueous solution as streaks in the liquid. Again, that there might be a slight difference in the concentration of the upper and lower, or of the warmer and cooler parts of a solution has also been shown. That a very considerable difference in concentration can be produced by centrifugal action was proved only last year by the experiments of Calcar and de Bruyn, in which solutions contained in rapidly rotating vessels became more concentrated in the portions furthest from the axis of rotation.

Schweig has recently suggested that the crystals which fall to the bottom of a rock-magma may be unstable compounds, which redissolve when the pressure is relieved, and so give rise to an underlying magma of different chemical constitution.

Harker, also, some time ago, suggested the existence of horizontal layers of different liquid magmas above each other, thus attempting to explain the presence of quartz in basic rocks as due to the crystals which had sunk into the basic magma from a more acid magma floating upon it.

The second theory, that of liquid differentiation, regards such layers as actually produced by the spontaneous division of a magma into two liquids of different composition, and if it be tenable seems more capable of explaining the geological facts.

The experiments bearing on the subject are well known, and have been quoted by Bäckstrom and Teall; mixtures of phenol and water, or of aniline and water, which form a homogeneous solution above a certain temperature, may below that temperature (which is a sort of critical point of the solution) divide into two solutions, one consisting of phenol in excess of water, the other of water in excess of phenol; and these two solutions are not miscible, but separate into two distinct layers.

Many pairs of substances have now been found to exhibit this incomplete miscibility, which varies with the temperature and may at certain temperatures become complete; among them are some of the metals such as zinc, lead, bismuth, and silver.

If rock-magmas can really behave in this way, there is no difficulty in explaining their differentiation; but experiments upon fused silicates have not disclosed anything of the sort, though they are made far below the critical temperature.

The case of nicotine and water, which has recently been described by Hudson, is remarkable and suggestive: above a temperature of 205° a mixture in equal proportions is a clear liquid; at 205° it divides into a saturated solution of nicotine in water floating on a saturated solution of water in nicotine; at 90° these two layers change places; at 64° they mix again and the liquid becomes once more homogeneous.

It is, of course, possible that fused silicates at experimental temperatures correspond to nicotine and water below 64°, and that rock-magmas correspond to the same mixture at higher temperatures.

In discussing the reasons why in laccolites of the Square Butte type the margin should be more basic, and in laccolites of the Magnet Cove type more acid than the centre, Washington regards the magma as a mutual solution of an alumo-alkaline substance with a ferro-magnesian substance; whichever of these is in excess may be regarded as solvent, and crystallises first, for example, either the syenite or the shonkinite. In a laccolite where no differentiation has taken place, as in the Henry Mountains type, he supposes the mixture to be eutectic or such that they crystallise together. Pirsson, in a paper recently published upon the "Highwood Mountain Laccolites of Montana," while attributing a greater part in the process to the action of convection currents, also regards the ferro-magnesian minerals, taken together, as constituting the solvent and crystallising first as shonkinite.

In fact, stated quite baldly, these latest views tend to a compromise between the two theories which I have just mentioned. They regard the splitting of the magma as produced by a fractional crystallisation, only now the mass which crystallises is not a mineral but a rock; in other words, they assume that rocks may be dissolved in each other, and may crystallise from each other as though they were minerals.

In this matter of magmatic differentiation, then, there has been during the last few years a large accumulation of geological evidence, a little new speculation, but practically no new experimental work, and scarcely any progress.

Mineral Differentiation and Eutectics.

Let us pass to the second petrographical problem, that of mineral differentiation, the nature and order of the minerals which crystallise when a cooling magma becomes a solid rock-mass.

It has been laid down by Rosenbusch, and is accepted as a general rule (in spite of many exceptions), that the order in which the various minerals crystallise is one of increasing acidity, ores and oxides and so-called accessory minerals first, then those minerals which are comparatively poor in silica, then those which are richer, and finally, if it be present in excess, the silica itself. It has also been supposed that the order may be one of the fusibility of the various minerals under the conditions of their formation; the least fusible minerals being the earliest to crystallise, and the most fusible the latest. Interesting speculations concerning the melting-point of quartz at high pressures, and its consequent order of crystallisation, have, for example, been published recently by Stromeyer and Cunningham.

It is not necessary, however, to regard the molten magma as a mere mixture of fused minerals which solidify more or less independently and consecutively; it is more reasonable to regard the whole magma as a solution in which the various minerals are dissolved, and from which they crystallise as it cools. Now the temperature at which a substance separates from solution is generally far below its melting-point, and the order in which the constituents of a mixed solution will crystallise is the order of their solubility in it, and bears no direct relation to their fusibility or to their chemical composition.

Teall in 1901, after discussing the controversies and the evidence on which they are based, came to the conclusion that rock-magmas are solutions, and that the order in which the minerals consolidate depends upon the nature of the constituents and their properties, and is not by any means the order of their freezing-points. As to the particular minerals which crystallise, he thought that the molecular grouping in the magma is determined by mass action and by the mutual affinities of the bases, the silica, and the alumina. Concerning future research he ventured to predict that the next advances were to be made by experiment controlled by the modern theory of solutions.

Thirteen years earlier Teall had himself contributed a valuable suggestion based upon Guthrie's work on cryo-hydrates. When a mixture of nitrate of lead and nitre is fused and allowed to cool, the constituent which is in excess will crystallise out as from a solvent until the proportions left in the liquid state are 47 of lead-nitrate to 53 of nitre, and this mixture will then solidify at 207°, not as a uniform compound, but as an intimate mixture of the two salts, the *eutectic*, which crystallises at the lowest possible temperature, and is the only mixture which has exactly the same composition as the liquid from which it solidifies. Teall made the illuminating suggestion that micropegmatite is an eutectic consisting of quartz and felspar, and represents in certain rocks the final mother liquor from which the other minerals have crystallised out. Eutectics in metallic alloys have been much studied during recent years; in the Address of 1901 Teall was able to strengthen his case by showing that spherulitic and micropegmatitic structures found in obsidian and other acid rocks are paralleled by similar structures developed in eutectic alloys, according as they have been rapidly or slowly cooled.

In the following year appeared a theoretical paper by Meyerhoffer concerning the ideal case of a molten mixture of two substances, *a* and *b*, which do not suffer double decomposition, nor form a double salt, nor an isomorphous mixture.

Let a diagram be constructed, with temperatures as ordinates and composition of the magma as abscissæ, giving by a curve the nature of the magma which is in equilibrium with either solid *a* or solid *b*. The curve has the form of a V; one arm represents the temperature and constitution of the liquid which can be in equilibrium with *a*, and the other that of the liquid which can be in equilibrium with *b*; and the lowest point corresponds to the eutectic, which is in contact with both.

Let a point above the curve represent the temperature and constitution of the liquid magma containing excess of *b*; as the magma cools this point descends to the *b* branch and travels along it while *b* is crystallising out, until the eutectic point is reached, when *a* and *b* both crystallise out together at a temperature below the melting-point of either. The order of crystallisation is therefore determined solely by the composition of the magma as compared with that of the eutectic. If, however, the liquid be cooled slowly, crystallisation may be postponed until it has become supersaturated with regard to one constituent or the other, or both; a state of affairs represented by a prolongation of the arms of the V below its lowest point, and then the order of the crystallisation may be inverted.

In a rock-magma there are of course many other factors to be taken into account as determining the order in which the minerals separate; for example, the formation of both double salts and isomorphous mixtures, the possible production of unstable solid compounds which may become converted into stable compounds or may be redissolved soon after they have come into existence; and also the relative velocities of crystallisation, changes of temperature and pressure, action of steam, etc.; but the principle laid down by Meyerhoffer must be that which controls the process.

It might be objected that on this hypothesis the consolidation of every rock-mass ought to terminate with an eutectic mixture, whereas this appears to be by no means the case; in fact, it is only among some acid rocks that structures much resembling the eutectic mixtures of alloys are to be found. On the other hand, if the conditions of cooling are such that the magma becomes supersaturated with one mineral after another, it will overshoot the eutectic composition before each crystallises, and the final consolidation may be a well-marked sequence instead of a simultaneous crystallisation.

The controversies which have raged concerning the classification of rocks and their nomenclature appear to me to contribute little to the real advancement of knowledge. There are, I think, two more profitable lines of research which should accompany each other. We may take the facts as we find them, and endeavour to explain them by the known laws of solutions aided by the phase-rule, provided that we have good reason to believe that rock-magmas behave like solutions, and we may make experiments upon slags and fused silicates and ascertain how far they resemble natural rocks in their behaviour and their mineral constitution. Some of the workers in this field have been led to regard rock-magmas as undoubtedly similar to ordinary solutions; others hesitate to seek an explanation for their features in the laws which govern the solutions studied in the laboratory. The two views are represented in the persons of the two men whose names are most closely identified with recent experiments, Vogt of Christiania and Doelter of Graz.

(*To be continued.*)

II.—MINERALOGICAL SOCIETY OF LONDON.

MINERALOGICAL SOCIETY, June 14th, 1905. Professor H. A. Miers, F.R.S., President, in the chair.—The Chemical Composition of Lengenbachite, by Mr. A. Hutchinson. A quantitative analysis of the new mineral from the Binnenthal, recently described by R. H. Solly, leads to the formula $7\,\mathrm{Pb\,S},\ 2\,\mathrm{As_2\,S_3}$, part of the lead being replaced by silver and copper and part of the arsenic by antimony.—The Chemical Composition of Hutchinsonite, by Mr. G. T. Prior. Chemical examination of this new and extremely rare mineral from the Binnenthal, described by R. H. Solly, showed that it could be added to crookesite and lorandite as a third mineral containing the rare element thallium as an important constituent. Quantitative analysis, made on a small amount of material (about 70 mgr.), showed the presence of about 20 per cent. of thallium and suggested the formula $\mathrm{(Tl, Cu, Ag)_2\,S\,As_2\,S_3 + Pb\,S\,As_2\,S_3}$.—The identity of the Amiantos of the Ancients with Chrysotile, by Dr. J. W. Evans. The principal source of amiantos appears to have been Cyprus. Specimens brought by Prof. Wyndham Dunstan from the ancient workings on the slopes of Mount Troodos prove to be chrysotile and not tremolite asbestos. A chemical analysis by G. S. Blake confirmed this result.—Gnomonic Projection on two Planes at Right Angles, by Dr. J. W. Evans. By means of these projections and the rotation of one plane on an axis at right angles to the other, simple solutions of crystallographic problems are obtained.—The President exhibited supersaturated solutions of sodium nitrate, showing the transition from the metastable condition, in which crystallisation is only possible in the presence of solid crystals, to the labile condition, in which the liquid can crystallise *spontaneously*.

III.—Palæontographical Society.

The fifty-eighth annual general meeting of the Palæontographical Society was held at the Geological Society's apartments, Burlington House, on Friday, 16th June, Dr. Henry Woodward, F.R.S., President, in the chair. The annual report of the Council and the balance-sheet were submitted for the approval of the members, and they were adopted on the proposition of Sir Archibald Geikie, Sec. R.S. The report congratulated the Society on its continued prosperity, and alluded to the activity of its members in the promotion of research. The Council were still embarrassed by more offers of memoirs than they could accept for immediate publication, and they had again spent a large sum beyond their income on the volume for 1904. This volume contained an unusual amount of letterpress with expensive tables, and was devoted to continuations of the Monographs of Old Red Sandstone Fishes, Inferior Oolite Ammonites, Carboniferous and Cretaceous Lamellibranchs, Girvan Trilobites, and British Graptolites. The Council had carefully considered the financial position of the Society, and had decided to issue a comparatively small volume for the year 1905. They proposed in future to end the financial year on 31st December instead of 31st March, so that the year should correspond exactly with the period to which the annual guinea related. They also proposed that in future the price of the annual volume to non-subscribers should be twenty-five shillings net. Dr. Henry Woodward was re-elected President, and Mr. E. T. Newton a new Vice-President; Dr. G. J. Hinde and Dr. A. S. Woodward were re-elected Treasurer and Secretary respectively. Professor W. J. Sollas, Mr. F. W. Harmer, and Mr. P. Lake were elected new members of Council.

CORRESPONDENCE.

THE CORRELATION OF THE BOVEY LIGNITE BEDS.

Sir,—In the periodical discussions that take place on the Bovey Lignite Beds, it seems always taken for granted that the late William Pengelly believed them to be of Miocene age, and not connected with any other known British beds. In 1865 Pengelly published his paper "On the Correlation of the Lignite Formation of Bovey Tracey, Devonshire, with the Hempstead Beds of the Isle of Wight" (Trans. Dev. Assoc., vol. i, pt. 4, p. 90), and observed that "they are all Lower Miocene or all Upper Eocene; for they must certainly go together." He tells us that Mr. Keeping, who made the excavations at Bovey, collected for him plant-remains at Hempstead, and that, of ten species secured, four occurred at Bovey, two were new to science, and two were new to Hempstead. One of the Hempstead and Bovey plants was *Sequoia Couttsiæ.*

It will be seen that thirty years ago Pengelly linked the Bovey and Hempstead Beds together as what are now known as Oligocene; but Mr. Starkie Gardner has since then for weighty reasons referred the Bovey Beds to the Bournemouth horizon as Eocene. My reason in writing on the subject is that Pengelly's Hempstead flora seems to have been overlooked. Indeed, in a recent text-book I cannot find either Hempstead or its beds, unless Hempstead has turned into Hamstead.[1] As the collection seems to have been specially made for Mr. Pengelly, and he recorded it in a paper of four pages in provincial transactions, its burial may have been too effective.

With regard to sands suspected to be of Dartmoor origin, the question can be readily settled by the character of the inclusions in the quartz. With respect to the Bovey clays, the presence of the kaolin at Bovey is exactly matched by its absence from its place on Dartmoor, where there is much evidence of the dissolution and removal of the felspar. This might be looked for with a semi-tropical vegetation and much consequent carbonic acid.

Referring to the Rev. Osmund Fisher's interesting note about the pink felspar crystals, which he suggests may have been derived from the English Channel area, he might be interested to examine the collection of rocks from the English Channel which were graciously accepted by the Woodwardian Professor, now many years ago. There was no evidence in the Channel of rocks likely to decompose and liberate pink felspar crystals. No. 2, with "large pale flesh-coloured orthoclase twins," is a hard rock. There is an abundance of red felspars on Dartmoor, ranging from a dark brick red; but these run in shades of red rather than pink, and are, so far as I am aware, not orthoclase. Moreover, if associated with quartz, they could be authoritatively distinguished from the Channel felspars, so far as those are known.

I feel an apology is due for my thus trespassing on your space on a subject which, except indirectly, is foreign to my own lines of inquiry. Of the Eocene and Miocene floras I am profoundly ignorant, but the discrimination of sands derived from the Channel and from Dartmoor is a simple matter in many cases. If sands contain chlorides we may be sure they were not derived from rocks known in the Channel; whereas if chlorides are entirely absent we may be equally sure they do not hail from Dartmoor.

The problem of the flora is as follows:—According to Pengelly and Keeping the Bovey Beds are equal to the Hempstead Beds, and are Tongrian. According to Mr. Starkie Gardner the Bovey Beds are equal to the Bournemouth Beds, and are Lutetian. Hence, according to Euclid, Tongrian must be equal to Lutetian, or Oligocene = Eocene, "which is absurd." The most obvious solution is that Euclid is a discredited text-book, and that things which are equal to the same things are not equal to one another. A plausible explanation would, however, assume that Pengelly misnamed his Hempstead fossil plants; but it is clear they were described by some expert specialist, as new species were detected. A. R. Hunt.

July 11th, 1905.

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[1] [The original name for the locality in the Isle of Wight is Hamstead, which was changed by the Survey into Hempstead.—Edit. Geol. Mag.]

PRE-GLACIAL BEACHES OF BRIDLINGTON AND S. OF IRELAND.

SIR,—In the July number of the GEOLOGICAL MAGAZINE, Mr. A. R. Hunt, in a paper on "The Geological Physics of the Shallow Seas," contrasts the pre-Glacial beaches of Bridlington and of the South of Ireland, and says, "But in the Irish beaches . . . . we have, much further south, the rock-platform itself ice-scored, affording no accommodation for hippopotami." These ice-scorings, however, occur only where a deposit of boulder-clay lies immediately on the platform, and, whatever may be the direction of the coast, the direction of the striæ on the platform remains parallel to those occurring under boulder-clay on higher ground inland. Nothing was seen to suggest that striæ occurred between the beach-platform and the beach-gravel, or that the beach-gravel had ever been disturbed by ice before the accumulation of the lower 'head.' The striæ, therefore, are not of the same age as the beach, and do not indicate the prevalence of glacial conditions during the formation of the beach. As at Bridlington, the beach "need not represent so cold a climate as that which followed." In this point, as in so many others, the South of Ireland pre-Glacial beach agrees with that of Bridlington. Consequently there is no reason from considerations of climate why the Irish cave fauna should not be found in the Irish coast-sections in a position similar to that of the mammalian remains in the Bridlington section. Nor do the "shells with a southern range on Devonshire beaches of the same levels" afford an obstacle to the correlation of these with the Irish beaches. The erratic pebbles found in the Irish beaches are not against this correlation, since erratics are also found in the Devonshire beaches.

GLENCOE. H. BRANTWOOD MUFF.
July 22nd, 1905.

MUSEUM BOLTENIANUM, PART 2, 1798.

SIR,—The rarity of part 2 of this work, which relates to Mollusca, is well-known to students. In response to a number of enquiries it is proposed to reproduce a few copies, by photographic facsimile, from the Crosse copy now in the British Museum (Natural History).

The large number of pages (204) must render this a somewhat costly task, and we should be glad to know if any of your readers would care for a copy to be reserved for them at the price of £2 per copy.

The work would be done, under our supervision, by Mr. F. W. Reader.

The issue will be limited, numbered, and signed, and could be prepared for distribution during the Autumn.

It must be clearly understood that unless sufficient subscribers are forthcoming, no issue can be made.

Any intending subscriber should address Mr. E. R. Sykes, 3, Grays Inn Place, Grays Inn, London.

E. R. SYKES.
June, 1905. C. DAVIES SHERBORN.

THE
GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE V. VOL. II.

No. X.—OCTOBER, 1905.

ORIGINAL ARTICLES.

I.—Notes on the Geological Horizon and Palæontology of the 'Soapstone Bed,' in the Lower Coal-measures, near Colne, Lancashire.

By Herbert Bolton, F.R.S.E., Curator of the Natural History Museum, Bristol.

THE 'Soapstone bed,' which has yielded the specimens about to be described by Dr. Henry Woodward, was so named by the late George Wild. It is a thin band of light-grey shale lying from 4 to 7 feet above the 'Mountain Four Feet' mine in the neighbourhood of Colne and Trawden.

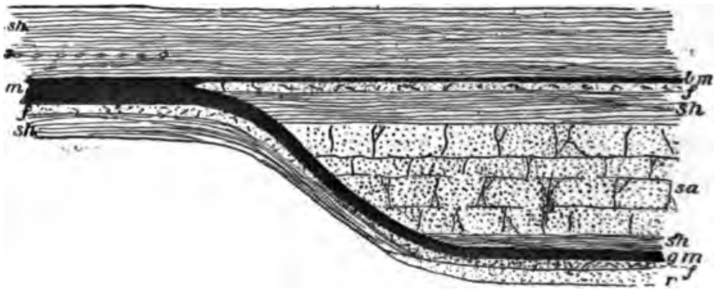
The shale contains an abundance of small flattened nodules, varying in size from half an inch to six inches in length, and from half an inch to two and a half inches in breadth. The vertical thickness rarely exceeds an inch and a half. The shale readily breaks down into a soft unctuous clay on weathering, whilst the outer surface of the nodules undergoes oxidation and breaks away in thin coats. The nodules consist of earthy carbonate of iron, and it is to the oxidation of the latter that breaking up takes place by a process of concentric scaling.

Between the 'Soapstone bed' and the 'Mountain Four Feet' mine are black shales with dark ironstone nodules often full of *Goniatites*, *Pterinopecten*, etc. The horizon from the top of the coal-seam to the 'Soapstone bed' is the most prolific in organic remains in the Lower Coal-measures, in whatever locality it may be met with.

Whilst the horizon of the Soapstone nodule bed is constant over a large area, the beds immediately subjacent to it are not. The Mountain Four Feet mine, upon which it rests under and around the whole of the Burnley coalfield, is seen when traced southwards to be formed by the union of two coal-seams, the 'Gannister mine' and the 'Bullion mine' respectively. These, in the Rossendale area, are separated by a thickness of 40 feet of sandstone and shale, which thins out along a north-west and south-east line between Bacup and Burnley, the thinning out being due to the curving upwards of the lower or Gannister seam to meet the overlying Bullion mine.

Although the Bullion mine can be traced southwards to Oldham, westwards to Padiham, and over the whole of Rossendale, its prolific yield of fossils both in nodules and in the surrounding shales is everywhere remarkable. The 'Soapstone bed' has not been recognised, however, outside the Burnley area, but the occurrence of an Arachnide, *Architarbus subovalis*, from this level at Padiham, would seem to indicate its presence there.

The shales lying upon the Bullion seam outside the Burnley district and those lying upon the Mountain Four Feet in that area are thus one continuous deposit, and have yielded more than thirty-five species of fossils. The chief repository of fossils lies between the roof of the coal-seam and the 'Soapstone bed.' Above the latter there is a marked falling off in genera and species.



Diagrammatic Section showing position of 'Soapstone bed' and relation of the 'Mountain Four Feet' to the 'Bullion' and 'Gannister' mines.

sh. shale; *s.* Soapstone bed shale; *m.* Mountain Four Feet mine; *f.* fireclay; *bm.* Bullion mine; *sa.* sandstone; *gm.* Gannister mine; *r.* Gannister rock.

The nodules of the 'Soapstone bed' are usually of small size, the average being about two inches long by one and a quarter inches wide. The great bulk of them contain a compact mass of the Goniatite, *Dimorphoceras Gilbertsoni*, Phillips, varying in diameter from that of a millet-seed to fifteen millimetres, the latter size being rare. More rarely, the nodules contain bones and scales of fishes, and, rarest of all, examples of Arachnida, Myriopoda, Crustacea, and Amphibia. A census of the Lower Coal-measure fauna was drawn up two years ago by the writer, from which the following lists of fossils occurring in the shales between the coal-seam and the 'Soapstone bed' and in the 'Soapstone bed' itself have been extracted.

SHALES OVER 'FOUR FEET' AND 'BULLION' MINES.

Discina orbicularis, Bolton.
Lingula mytiloides, Sow.
Posidoniella lævis, Brown.
,, *minor*, Brown.
,, *subquadrata*, Hind.
,, *lævigata*, Salter.
Pterinopecten papyraceus, Sow.
Raphistoma (?) *ornata*, Bolton.
Naticopsis globularis, Bolton.
Glyphioceras paucilobum, Phillips.
Dimorphoceras Gilbertsoni, Phillips.
Gastrioceras carbonarium, von Buch.
,, *Listeri*, Martin.
,, *coronatum*, Foord & Crick.
Acanthodes Wardi, Egerton.
Listracanthus spinatus, Bolton.
Rhizodopsis sauroides, Williamson.
Cœlacanthus elegans, Newberry.
Elonichthys semistriatus, Traquair.

Fossils from 'Soapstone Bed.'

Dimorphoceras Gilbertsoni, Phillips.
Pygocephalus Cooperi, Huxley.
Prestwichia rotundata, H. Woodw.
Architarbus subovalis, H. Woodw.
Hybodopsis Wardi, Barkas.
Acanthodes Wardi, Egerton.
Elonichthys Aitkeni, Traquair.
Hylonomus Wildi, A. S. Woodward.
Microsaurian remains unidentified.

It will be seen that the fauna of the 'Soapstone bed' differs markedly from that of the underlying shales, although a few forms are common to the two.

Further examination of the bed cannot now be made in the neighbourhood of Carre Heys, as the mines have been long abandoned, and nothing remains but the grass-grown spoil-heaps of débris now reduced to a condition of soft clay in which the small nodules can occasionally be found.

The following list includes most, if not all, of the allied genera and species already recorded from the Lancashire Coal-measures :—

Anthrapalæmon Etheridgei, Peach, Trans. R. S. Edinb., 1880, vol. xxx, pp. 76–78, pl. viii, figs. 3*a*–*g*.

A cephalothorax of this species was found high up in the Lower Coal-measures of Cant Clough, near Burnley, in 1884.

Pygocephalus Cooperi, Huxley, Quart. Journ. Geol. Soc., 1857, vol. xiii, p. 363, pl. xiii; 1862, vol. xiv, p. xci; vol. xviii, p. 420; see also H. Woodward, Trans. Geol. Soc. Glasgow, 1866, vol. ii, p. 234.

Found by the late George Wild in the 'Soapstone bed,' above the Mountain Four Feet coal, at Carre Heys, near Colne. A second specimen has been found in the Middle Coal-measures of Medlock Park Bridge, near Ashton-under-Lyne. Both examples are in the Manchester Museum of Owens College. A third specimen has been found by Messrs. Baldwin and Sutcliffe in an ironstone nodule-band occurring 60 yards above the Royley or Arley mine at Sparth Bottoms, Rochdale.[1]

Arthropleura (*olim Eurypterus*) *mammata*,[2] Salter, 1863, Quart. Journ. Geol. Soc., vol. xix, p. 84.

Fragments of this species belonging to the head, lateral portions

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[1] See Catalogue Type Fossils in Museum Handbook of the Owens College Museum, Manchester, by H. Bolton, 1893, where on p. 23 is a description and figure of the type-specimen of *Pygocephalus Cooperi*, Huxley. Eight specimens of this species have been obtained by the British Museum (Natural History) from Coseley Coalfield, near Dudley, in Mr. Henry Johnson's collection, etc.

[2] Remains of this genus have been discovered by Mr. James McMurtrie, F.G.S., in the Coal-measures of Radstock, Somerset, and by Mr. J. W. Kirkby in the Coal-measures of Fifeshire. They agree (according to Dr. Woodward) most closely with the *Arthropleura armata* of Jordan from the Coal-measures of Saarbruck, Rhenish Prussia (see Palæontographica, 1856, Bd. iv, Taf. 2, figs. 4 and 5), and from their peculiar pustulate, mammate, and spinous ornamentation may prove, when more remains have been obtained, to be parts of the body-segments of a large Arachnid. See Pal. Soc. Mon. Merostomata, by H. Woodward, pt. iv, 1872, pp. 163–168; *cf.* also figure and description of *Eurypterus scabrosus*, H. W., Geol. Mag., 1887, pp. 481–484, Pl. XIII, from Lower Carboniferous shales, Eskdale, Scotland.

of the body-segments, and parts near the tail were found at the pit top of Pendleton colliery by Messrs. Gibbs and Rhind. The horizon was afterwards found to be the 'ferny metal' under the Big Coal or Rams Mine.

Cyclus Johnsoni, H. Woodward, GEOL. MAG., 1894, p. 537, Pl. XV, Figs. 4–7.

A single specimen is recorded from the roof of the Fairbottom Mine in the Middle Coal-measures at Bardsley, near Oldham.

Cyclus Scotti, H. Woodward, GEOL. MAG., 1893, p. 28 (woodcut); ibid., 1894, p. 537, Text-figure, and Pl. XV, Fig. 3.

The type-specimen of this species was found by the late George Scott in shale over the Gannister coal at the Old Meadows colliery, Bacup, Lancashire (now preserved in the Owens College Museum, Manchester).

Prestwichia rotundata, H. Woodw., Quart. Journ. Geol. Soc., 1867, vol. xxiii, pl. i, fig. 1.

An example of this species is in the Kay-Shuttleworth Collection of the Manchester Museum. It was obtained from Padiham, near Burnley, and although its precise horizon is not recorded the writer regards it as undoubtedly just above the Mountain Four Feet mine.

Prestwichia Birtwelli, H. Woodw., GEOL. MAG., 1872, Vol. IX, Pl. X, Figs. 9 and 10; Pal. Soc. Mon. Merostomata, part v, 1878, p. 247, pl. xxxi, figs. 7*a*–*c*.

From the Cornfield Pit, River Calder, Padiham, near Burnley.

Bellinurus bellulus,[1] König, 1820 (*olim Limulus trilobitoides*, Buckland, 1836), H. Woodw., Pal. Soc. Mon. Merostomata, part v, 1878, p. 239, pl. xxxi, figs. 3*a*, *b*.

A specimen of this species was obtained many years ago from Coal-measures at Oldham, and deposited in the old Natural History Museum in Manchester. No horizon was stated, and the specimen cannot now be traced.

A second specimen has been found by Messrs. Baldwin and Sutcliffe at Sparth Bottoms, Rochdale, where it occurred 135 feet above the Royley or Arley mine of the Middle Coal-measures.

ARACHNIDA.

Architarbus subovalis, H. Woodw., GEOL. MAG., 1872, Vol. IX, p. 385, Pl. IX, Figs. 1*a*, *b*.

The type of this species was described by Dr. Henry Woodward in 1872, the specimen occurring in a clay-ironstone nodule lying about four feet above the 'four feet mine' or 'bone-coal' of Padiham. The horizon here given is that of the Soapstone bed, the 'four feet mine' being the Mountain Four Feet.

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[1] Dr. F. A. Bather suggests that this specimen ought to be called *Bellinurus lunatus*, Martin, sp., having been described by that author as *Entomolithus (Monoculus) lunatus* in his (Martin's) "Petrificata Derbiensia" in 1809, pl. xlv, fig. 4.

SCORPIONIDÆ.

Eoscorpius Sparthensis, Baldwin & Sutcliffe, Quart. Journ. Geol. Soc., 1904, vol. lx, pp. 394–399, figs. 2 and 3 in text.

The type of this species was found by Messrs. Baldwin and Sutcliffe at Sparth Bottoms, Rochdale, at 135 feet above the Royley or Arley mine of the Middle Coal-measures. (It is now in the Rochdale Museum.)

MYRIOPODA.

Euphoberia Browni, H. Woodw.,[1] GEOL. MAG., 1871, Vol. VIII, pp. 102–104, Pl. III, Fig. 6.

Found in shale in which the fossil tree trunks occur at Dixon Fold on the Lancashire and Yorkshire Railway. The horizon is, I believe, that of the shales lying over the Doe mine in the Middle Coal-measures.

Euphoberia ferox, Salter,[2] sp., 1863.

Remains of this species were found in association with *Arthropleura mammata* at the pit top of Pendleton colliery, the horizon being the 'ferny metal' under the 'Big Coal' or Rams mine of the Middle Coal-measures. It has also been found by Messrs. Sutcliffe and Baldwin at Sparth Bottoms, 45 yards above the Royley mine.

Xylobius sigillariæ, J. W. Dawson,[3] 1860, Quart. Journ. Geol. Soc., vol. xvi, pp. 268–277.

A specimen (species undeterminable) is in the Manchester Museum, having been obtained from the waste-heaps of the Ashton Moss colliery by Mr. Robert Cairns.

Insecta are represented by an imperfect specimen of a Neuropterous insect from 47 yards above the Royley or Arley mine at Sparth Bottoms, Rochdale, and a doubtful larval form of *Etoblattina* from about 60 yards over the Royley or Arley mine at the same place. Both specimens were found by Messrs. Baldwin and Sutcliffe.

II.—NOTES ON SOME CRUSTACEANS AND TWO MYRIOPODS FROM THE LOWER COAL-MEASURES NEAR COLNE, LANCASHIRE.

By HENRY WOODWARD, LL.D., F.R.S., F.G.S.

BY the courtesy of my friend Mr. Herbert Bolton, the Curator and Secretary of the Bristol Museum, several specimens have been placed in my hands for examination. They were collected by Mr. Peter Whalley from the 'Soapstone bed,' a little distance above the 'Bullion Mine' (or 'Mountain Four Feet'), on the hill near Colne, Lancashire, and he permits me to figure and describe them.

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[1] The type-specimen was obtained by the late Mr. Thomas Brown, of Glasgow, in a clay-ironstone nodule from the Coal-measures of Kilmaurs.

[2] Described as a *Eurypterus* by Salter, Quart. Journ. Geol. Soc., 1863, vol. xix, p. 86, really a spined Myriopod; see H. Woodward, "Myriopods of the Coal Period," GEOL. MAG., 1887, pp. 1-10 and 116-117 (figs. in text).

[3] A Chilognathous Myriopod from the hollow trunk of an erect *Sigillaria* in the South Joggins Coalfield, Nova Scotia. This genus was first found in Scotland by Mr. Thomas Brown in the Coal-measures of Kilmaurs, and described by Dr. H. Woodward in Trans. Geol. Soc. Glasgow, 1866, vol. ii, p. 234, pl. iii, fig. 11. A second specimen from the clay-ironstone band, Cooper's Bridge, was obtained by Mr. Joseph Tindall, of Huddersfield, and figured on the same plate (op. cit.), figs. 13 and 13*a*. Noticed by Mr. Edward Binney, F.R.S., Trans. Lit. and Phil. Soc. Manchester, Jan. 8th, 1867; see GEOL. MAG., 1867, Vol. IV, p. 132.

All the specimens are enclosed in small, elliptical nodules of clay-ironstone, evidently formed around the organisms by a process of concretionary action at the time of their embedment in the sediment forming the layer in which the nodules occur, the fossils being, as usual in such cases, exposed by splitting the concretions open along their periphery.

CRUSTACEA.

DECAPODA—MACROURA.

1. ANTHRAPALÆMON SERRATUS, H. Woodw., sp. nov.

(Text-fig. 1.)

This specimen is represented by only a portion of one side of a nodule; the remainder and counterpart are alike wanting.

The Crustacean is disposed longitudinally on the split surface of the matrix, and is 90 millimetres in length, of which the cephalothorax measures 50 mm. long, and the five abdominal segments 40 mm.; the rostrum, which is smooth, sharply pointed, ridged, and slightly curved downwards in front, is 20 mm. in length, the anterior border on the left side is 11 mm. broad; the antennules and antennæ are only imperfectly preserved; the outer antenna was furnished with a broad, recurved spatulate scale 14 mm. in length. The outer latero-anterior margin bears four short serrations, but the rostrum appears to have been quite smooth. Only four of the five pairs of ambulatory legs are imperfectly preserved, but the presumably larger anterior chelate pair, if present, are not visible in the fossil.

The latero-posterior border of the carapace is slightly rounded off, and the margins raised and thickened. The median line of the five abdominal segments is slightly raised, and the lateral margins truncated. If epimeral pieces existed to these segments they are hidden in matrix or are not now preserved. The caudal segment and appendages are wanting. The surface of the body-segments is finely punctate; the surface of the cephalothoracic shield has doubtless adhered to the other, lost side of the split nodule. A very small maxilliped with a three-jointed palpus attached appears lying on the surface of the cephalothorax where the carapace has been removed (unfortunately this is not shown in Fig. 1).

This specimen approaches most nearly to Dr. B. N. Peach's *Anthrapalæmon Etheridgei*[1] from the Carboniferous rocks of Eskdale, but in the latter the rostrum bears a row of four or five well-marked small spines, and the extremity is also serrated on each side, the antennal scales are more oval in form, not so obliquely curved and spatulate as in our specimen, nor is the border of the cephalothorax serrated along the latero-anterior margin as in this example from Colne. I am therefore inclined to separate this form specifically, giving it the trivial name of *serratus*.

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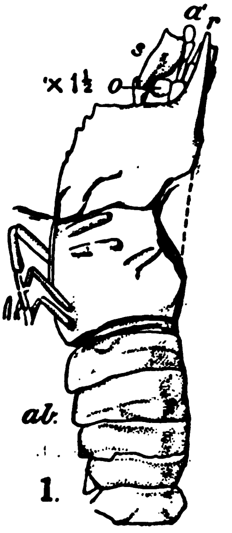
[1] Trans. R. S. Edinb., 1880, vol. xxx, pp. 76–78, pl. viii, figs. 3*a*–*g*.

Locality and formation: 'Soapstone bed,' a little distance above the Bullion Mine, Colne Hill, Lancashire. Lower Coal-measures. Collection of Mr. Peter Whalley.

2. ANTHRAPALÆMON WOODWARDI, R. Etheridge, jun., 1879. (Text-fig. 2.)

Quart. Journ. Geol. Soc., 1879, vol. xxxv, p. 468, pl. xxiii, figs. 4–9.

Among a number of Lower Carboniferous Crustaceans from the cement-stone of the Calciferous Series near New Castleton, Roxburghshire, Mr. Robert Etheridge figured and described, in 1879, several examples which he referred to this species (originally figured from a less perfect example, Quart. Journ. Geol. Soc., 1877, vol. xxxiii, p. 872, pl. xxvii).



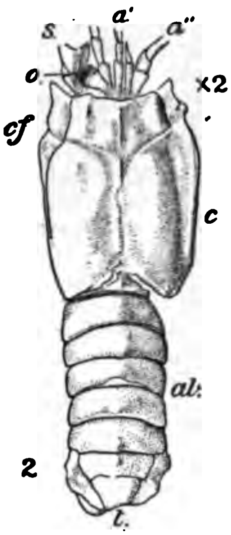


FIG. 1.—*Anthrapalæmon serratus*, H. Woodw., sp. nov. Enlarged 1½ nat. size. Soapstone bed, Lower Coal-measures: Carre Heys, Colne, Lancashire. *a'*, antennule; *s*, scale at base of antenna; *r*, rostrum; *o*, eye; *ab*, abdomen.

FIG. 2.—*Anthrapalæmon Woodwardi*, R. Etheridge, jun., 1879. Formation and loc. same as Fig. 1. *a'*, antennule; *a''*, antenna; *o*, stalked eye; *cf*, cervical furrow; *c*, cephalothorax; *ab*, abdomen; *t*, telson or caudal segment.

The following is Mr. Etheridge's description:—

"Sp. char. Carapace oblong, narrowing towards the anterior part, and divided into two unequal portions by the cervical groove, the posterior being the largest; relative convexity unknown. Anterior lateral margins[1] not spinous and without serrations; posterior lateral angles rounded; posterior margin concave. Cervical groove strongly marked and widely V-shaped. Middle line of the carapace occupied by a strong ridge continuous with the rostrum and extending to the posterior margin, and flanked on each side by a straight or slightly curved lateral ridge extending from the frontal border to the posterior margin. Like the central one, these ridges are minutely crenulated. That portion of the carapace anterior to the cervical groove is crushed, and cannot satisfactorily be made out." [Mr. Etheridge thought this form probably possessed a prominent rostrum, but the figures given on his pl. xxiii, op. cit., do not represent anything more than a very slight double spine.[1]]

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[1] Produced at antero-lateral angles into a spine (see Fig. 2 above).

"Flagella of the antennæ bent obtusely outwards, composed of numerous minute subdivisions. Antennæ having a peduncle or protopodite of four segments, and terminating in two slender filamentous whips. First pair of chelate appendages probably present, small, elongate. Eyes large and reticulated. Abdominal segments six in number, with pointed pleuræ[2] and a well-marked central line extending throughout their whole length, and corresponding with the central ridge of the carapace; articular area small, but distinctly visible, defined by a small transverse ridge on each segment. Telson primarily consisting of a central hastiform plate, flanked on each side by two lateral caudal swimming-lobes, which arise from and are articulated to the sixth segment of the abdomen."

I do not think I need add a further description to that by Mr. Etheridge. The impressions left by the rather large eyes, the basal joints of the antennules, and the outer antennæ, with portions of their flagellæ, can be made out. The small limbs are not preserved in this specimen, nor the chelate anterior pair.

Length of Mr. Whalley's specimen 65 mm., length of cephalothorax 33 mm., breadth 22 mm., length of five abdominal somites 20 mm., length of second abdominal segment 7 mm., length of caudal plates 10 mm. (probably longer).

Locality and horizon: Colne Hill, Soapstone bed, Lower Coal-measures. Original specimen in Mr. Peter Whalley's collection.

3. ANTHRAPALÆMON TRAQUAIRII (?), Peach.

Trans. Roy. Soc. Edinburgh, 1880, vol. xxx, pt. 1, p. 80, pl. x, figs. 5*a*–*f*.

In Mr. Whalley's collection is a rather large Arthropod, probably referable to Dr. Peach's species *A. Traquairii*, from the Lower Carboniferous rocks of Eskdale. The specimen is very obscure, and I have therefore not figured it; but a brief note may serve to record it, and to stimulate further research, which it may be hoped will result in the obtaining of more perfect material for study.

The whole animal measures 8½ cm. in length, by 2 cm. in breadth. The carapace is 3½ cm. long, and appears to have slipped forward in the matrix (when soft) exposing 2 cm. length of the uncovered thoracic region with the imperfectly preserved thoracic limbs; behind these, again, are the traces of the five abdominal somites; the nodule

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[1] The presence of a rostrum is not confirmed by Mr. Whalley's specimen, and I am doubtful whether this species had a prominent rostrum.

[2] The pleuræ cannot be seen in Mr. Whalley's specimen.

has been truncated just where the caudal appendages would join the abdominal segments. The carapace is rounded posteriorly, and the cervical furrow is well-marked. There is also a median dorsal furrow down the centre of the carapace. The limbs are very imperfect. Two obscurely defined scale-like bodies are present in front of the head.

We can only hope for better material from the Soapstone nodules, to enable one to determine this interesting fossil.

Locality and formation, the same as the preceding specimens.

TRACHEATA (Air-breathers of the Coal Period).

ARCHIPOLYPODA, Scudder.

Fam. 2.—EUPHOBERIDÆ, Scudder.

Genus EUPHOBERIA, Meek & Worthen.

Palæontology of Illinois, 1868, p. 556.

1. EUPHOBERIA BROWNII, H. Woodw., 1871.

GEOL. MAG., Vol. VIII, Pl. III, Figs. 6a–c (in clay-ironstone, Coal-measures, Kilmaurs, near Glasgow).

The specimen from Mr. Peter Whalley's collection of which a figure is given here (Fig. 3) is identical with *Euphoberia Brownii*, from Kilmaurs, figured and described by me in 1871.

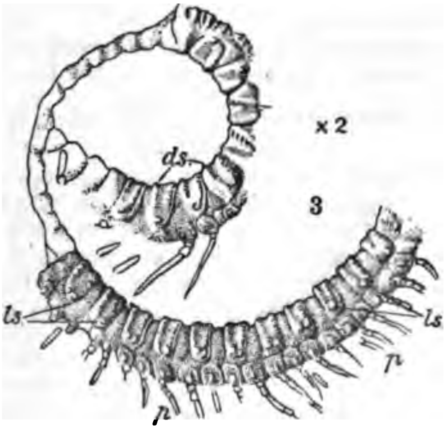

FIG. 3.—*Euphoberia Brownii*, H. Woodw., 1871. Enlarged twice natural size. From Soapstone bed, Coal-measures: Carre Heys, Colne, Lancashire. *ds*, dorsal surface; *ls*, bases of spines; *p*, *p*, walking-feet.

Both sides of the nodule from Colne Hill are preserved and expose a coiled up Myriopod, having indications of a head and about 30 equal-sized segments, each composed of a saddle-shaped plate rounded at its lower edge, covering the dorsal region and having a raised rounded border before and behind; the interlocking posterior smooth border is of equal breadth behind the saddle, the smooth margin of which passes under the succeeding segment; at the lower lateral rounded border of each saddle-shaped plate the base of a round spine (?) is seen broken off; occasionally the base is double. Some of the saddle-plates have a third additional ridge upon them. Below each saddle-shaped dorsal plate are two smaller ventral plates,[1] also ridged, to each of which a pair of slender, six- or seven-jointed walking-limbs is articulated. The saddle-plates of the segments nearest the head have a delicate crenulation along their raised margins. The head has two rounded lobes, which are probably the eyes, although the facets are not very distinct. The last segment (telson?) is smaller than the rest and appears to be somewhat semicircular in form; quite 15 to 20 pairs of jointed ambulatory appendages can be made out, two pairs being attached to each double segment.

Measured around the curve of the coiled-up specimen the body is 8 centimetres in length; the segments 10 mm. deep and about 8 mm. long; the walking-legs are about 10 mm. in length. There is a second specimen in Mr. Whalley's collection, with counterpart (broken off at each end), which measures 3 cm. in length.

Euphoberia Brownii is closely related to *E. armigera*, described by Messrs. Meek & Worthen in their great work on "The Geology and Palæontology of Illinois, U.S.," 1868, vol. iii, p. 556, figs. *a–d*, from the clay-ironstone nodules of the Coal-measures, Grundy County, Illinois, reproduced in our Pl. III, Geol. Mag., 1871, p. 104.

Locality and formation: from the Soapstone bed, Colne Hill. Lower Coal-measures. In the collection of Mr. Peter Whalley.

2. Xylobius moniliformis, H. Woodw., sp. nov.
(Text-fig. 4.)

The earliest recorded examples of Chilognathous Myriopods met with in a fossil state were discovered by Sir William Dawson in the hollow trunk of a still erect *Sigillaria*, in a bed of coal on the South Joggins Coalfield, Nova Scotia, and described by him in the Quarterly Journal of the Geological Society of London in 1853, vol. ix, p. 58. A fuller description by the same author followed December 15th, 1859 (op. cit., vol. xvi, p. 268). These terrestrial Myriopods have also been found in the Coal-measures of Illinois by Messrs. Meek & Worthen, and in the Coal-measures of Kilmaurs, near Glasgow, by Mr. Thomas Brown. Some of these forms were described and figured by me in the Trans. Glasgow Geol. Soc., 1866, vol. ii, p. 235, pl. iii, figs. 11–13.

In 1867 Mr. Binney exhibited fossils collected by Mr. Joseph Tindall, of Huddersfield, from the Lower Coal-measures near that town. One of these was a remarkably good example of *Xylobius* in a nodule of clay-ironstone, having about 46 well-preserved articulations to its body. This specimen showed the segments to have been ornamented with transverse, finely undulating lines, as noticed in the original examples from Nova Scotia, and I referred it in my description to Dr. Dawson's species *Xylobius sigillariæ.*[1]

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[1] Not clearly shown in the figure.

The specimen here figured (Fig. 4) from near Colne, Lancashire, shows only a part of the body of a Myriopod, consisting of about 25 rounded segments, truncated at the larger anterior end by the loss probably of the half of the nodule in which the animal is imbedded, the part preserved being the posterior or caudal moiety with its counterpart. Each somite or segment has a raised ring or ridge passing around near the anterior border, having (so far as exposed upon the matrix) a single row of upwards of 10 minute oblong bead-like ornaments on it, with a plain, slightly raised moiety forming the posterior articular boundary of each segment. Beyond the first 13 or more anterior segments, counting from the truncated end, the body-rings gradually diminish in size towards the posterior extremity, which is slightly curled round like the tail of the letter J. Length of the entire body about 6 cm. Length of six segments 20 mm., width of anterior segment 8 mm. Minute walking-legs, about 5 mm. long, are to be seen for almost the entire length of the body; there are two pairs (where preserved) to each segment.

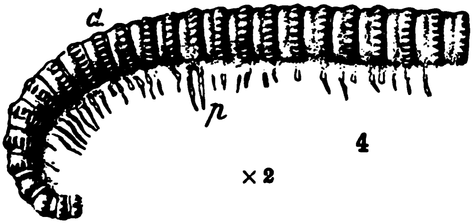

FIG. 4.—*Xylobius moniliformis*, H. Woodw., sp. nov. Soapstone bed, Lower Coal-measures: Carre Heys, Colne, Lancashire. Enlarged twice natural size. *d*, dorsal aspect of specimen; *p*, walking-feet.

The interest attaching to this specimen of *Xylobius* consists in the preservation of the extremely beautiful ornamentation on the body-segments, reminding one of the jointed columns of some Silurian Crinoid such as *Gissocrinus* or *Gothocrinus*. It is to be regretted that the remainder of the nodule has not been preserved, as we might then have been able to describe the head, and have ascertained the entire length of the body.

Locality and formation: Soapstone bed, Lower Coal-measures, Colne Hill, Lancashire. In the collection of Mr. Peter Whalley.

Amongst the nodules sent up by Mr. Whalley there is in one the remains of a fish, *Acanthodes Wardii*; another contains two very small Gasteropods which have not been identified.

Mr. G. C. Crick, F.G.S., has kindly examined two other nodules for me, and writes as follows:—

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[1] See Trans. Lit. and Phil. Soc. Manchester, January 8th, 1867; GEOL. MAG., 1867, Vol. IV, p. 132; and Trans. Glasgow Geol. Soc., 1866, vol. ii, p. 236, pl. iii, figs. 13 and 13*a*.

Dimorphoceras discrepans (T. Brown[1]).

In one nodule is exhibited about one-half of the lateral area and a portion of the periphery of the septate part of a Goniatite, 3 mm. in diameter, that seems to be referable to this species. The test is not preserved, but the septa are well shown.

Orthoceras, sp. 1.

In the same nodule as the example of *Dimorphoceras discrepans* there is a fragment of a slender, slowly-tapering *Orthoceras*, 8 mm. long and about 2 mm. in diameter. Rather more than the uppermost 2 mm. form part of the body-chamber; the rest is entirely septate and exhibits fifteen chambers, so that these may be described as very shallow, about five occupying the space of 2 mm. The septa are slightly oblique; the cross-section is elliptical; the siphuncle appears to be nearly marginal and situated at the extremity of the long axis. The test is thin and polished. *Orthoceras asciculare*, T. Brown,[2] is described as having the siphuncle near the side, but, judging from the figure, that species has deeper chambers than the present specimen.

Orthoceras, sp. 2.

Another nodule contains a fragment of a slender *Orthoceras*, about 6 mm. long. The specimen is only partially exposed, the greatest width being only 1·5 mm., but it seems to belong to a more rapidly tapering shell than sp. 1. Although nearly covered with the test, it appears to be entirely septate, the chambers being a little deeper than in sp. 1, eight chambers occupying about 5 mm. The test is thin, polished, and has very feeble annulations, which apparently correspond to the septa, whilst the surface between the annulations is covered with exceedingly fine transverse lines.

III.—Sedgwick Museum Notes.

New Fossils from the Haverfordwest District. IV.

By F. R. Cowper Reed, M.A., F.G.S.

(PLATE XXIII.)

THE following species of Brachiopoda were recorded by Messrs. Marr & Roberts[3] from the Ordovician beds of the Haverfordwest district:—

Llandeilo Limestone.
- *Leptæna* [*Plectambonites*] *sericea*, Sow.
- *Orthis striatula*, Conr.

Dicranograptus Shales.
- *Orthis argentea*, His.
- *Siphonotreta micula*, McCoy.
- and "other horny brachiopods."

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[1] T. Brown, Fossil Conchology, 1849, p. 28, pl. xxi, figs. 8, 8*a*, and 15 (*Goniatites discrepans*). See also Foord & Crick, Cat. Foss. Ceph. British Museum, pt. 3, 1897, p. 222 (*Dimorphoceras discrepans*).

[2] T. Brown, Trans. Manchester Geol. Soc., vol. i, 1841, p. 220, pl. vii, fig. 39; and T. Brown, Foss. Conch., 1849, p. 249, pl. xxix*, fig. 29.

[3] Marr & Roberts: Q.J.G.S., vol. xli (1885), pp. 476–491.

ROBBESTON WATHEN LIMESTONE.
Orthis elegantula, His.
,, *Actoniæ*, Sow.
,, *calligramma*, Dalm.
Leptæna [*Plectambonites*] *transversalis*, Wahl.
Strophomena [*Leptæna*] *rhomboidalis*, Wilck.

TRINUCLEUS SETICORNIS BEDS.
(*a*) SHOLESHOOK LIMESTONE.
Orthis elegantula, Dalm.
,, *testudinaria*, Dalm.
,, *calligramma*, Dalm.
Leptæna [*Plectambonites*] *quinquecostata*, McCoy.
,, [,,] *sericea*, Sow.
,, [*Christiania*] *tenuicincta*, McCoy.
Strophomena [*Leptæna*] *rhomboidalis*, Wilck.

(*b*) REDHILL BEDS.
Lingula sp.
Leptæna [*Plectambonites*] *sericea*, Sow.
,, [*Christiania*] *tenuicincta*, McCoy.
Strophomena [*Leptæna*] *rhomboidalis*, Wilck.
Orthis elegantula, Dalm.
,, *calligramma*, Dalm.

(*c*) SLADE BEDS.
Lingula sp.
Strophomena [*Leptæna*] *rhomboidalis*, Wilck.
,, *corrugatella*, Dav.
Leptæna [*Plectambonites*] *sericea*, Sow.
Orthis biforata, Schloth.
,, *elegantula*, Dalm.
,, *testudinaria*, Dalm.
,, *calligramma*, Dalm.
,, *porcata*, McCoy (?).

We are able to make the following additions to the foregoing list means of the large series of Brachiopods collected by Mr. V. M. rnbull, though the specific determination of many specimens robably including some new species) must await the acquisition better material.

I. LLANDEILO LIMESTONE.
Trematis multistriata, sp. nov. Lampeter Velfrey.
Strophomena sp. Lampeter Velfrey.

II. DICRANOGRAPTUS BEDS.
(*Orthis argentea* zone.)
Acrotreta Nicholsoni, Dav.
Orbiculoidea perrugata, McCoy.

III. ROBBESTON WATHEN LIMESTONE.
Plectambonites sericea, Sow.

IV. TRINUCLEUS SETICORNIS BEDS.
(*a*) SHOLESHOOK LIMESTONE.
Crania Turnbulli, sp. nov.
Orthis Actoniæ, Sow.
Triplecia insularis, Schloth.
Plectambonites scissa, Salt.

(*b*) REDHILL BEDS.
Orthis aff. *Bouchardi*, Dav.
Plectambonites scissa, Salt.
,, *papillosa*, sp. nov.
Strophomena antiquata, Sow., var.

(*c*) Slade Beds.
Lingula brevis, Portl. (?).
Lingula, two sp. indet.
Crania Grayi, Dav., var.
Orbiculoidea perrugata, McCoy.
,, (*Pholidops* ?) *oblongata*, Portl.
Orthis vespertilio, Sow.
,, *Sowerbyana*, Dav.
,, *crispa*, McCoy.
,, *Actoniæ*, Sow.
,, *porcata*, McCoy, var. nov. *sladensis*.
,, *testudinaria*, Dalm., var.
,, (several indet. sp.).
Triplecia insularis, Schloth.
Strophomena antiquata, Sow., var. *scabrosa*, Dav.
,, *expansa*, Sow.
,, *mediocostalis*, sp. nov.
,, sp.
Plectambonites papillosa, sp. nov.
Atrypa imbricata, Sow.
Meristella cf. *crassa*, Sow.
Hyattella pentagonalis, Reed (?).
Zygospira Hicksi, sp. nov.

Trematis multistriata, sp. nov. (Pl. XXIII, Figs. 1, 1*a*.)

Description.—Shell nearly orbicular, a little wider than long. Brachial valve gently convex, most so towards beak, which is marginal and slightly projects over posterior margin. Surface of valve covered with fine, raised, thread-like lines radiating from the beak, and increasing in number towards margin by interpolation of secondary and tertiary shorter lines at half, or a quarter, or less than a quarter the length of the primary lines. All lines of equal strength and at equal distances, the interspaces being about twice the width of the lines. The median lines are straight, but towards the cardinal region the lines curve gently backwards. Interspaces between radiating lines occupied by small transversely rectangular or subquadrate pits, a single row lying along each interspace, and separated by small low transverse bars. The radial threads number on margin about 200. A few low concentric growth ridges are present on the surface.

Dimensions.

Length	16·5 mm.
Width	18·5 mm.

Locality.—Quarry near Church, Lampeter Velfrey.

Horizon.—Lower Llandeilo Limestone.

Remarks.—This beautifully ornamented shell is closely allied to *Trematis siluriana*, Dav.,[1] but the radial lines are rather more numerous and closer together, the interpolation of secondary and tertiary lines less regular, the pits less conspicuous, and the beak more marginal. The shell is well preserved in our specimen, but unluckily we know nothing of the internal characters nor of the opposite valve. *T. ottawaensis*, Billings,[2] from the Trenton Limestone, appears to be a nearly allied form, but, apart from the presence of the pits, the shape of the shell, position of beak, and radial ornamentation resemble *Schizocrania filosa*, Hall.[1] However, the generic position of our specimen does not admit of a doubt. It appears to be specifically distinct from any so far described, none of the other British species, except *T. siluriana*, being closely allied, and the name *multistriata* is therefore proposed for it.

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[1] Davidson: Mon. Brit. Foss. Brach., vol. iii, p. 71, pl. vi, figs. 8, 8*a*, 8*b*.

[2] Billings: Pal. Foss. Canada, vol. i (1862), p. 53, fig. 58.

CRANIA TURNBULLI, sp. nov. (Pl. XXIII, Figs. 2, 2*a*.)

DESCRIPTION.—Shell subquadrate, wider anteriorly, upper valve strongly elevated, convex, subpyramidal; apex situated nearer anterior than posterior margin; posterior slope somewhat flattened; anterior slope short, steep. Cast of interior of upper valve showing pair of anterior adductor muscle-scars situated a little behind apex, nearly in middle of shell, less than their own diameter apart, deep, subcircular, each partly divided internally into two subequal portions by a triangular projection from outer anterior side. Pair of shallow oval posterior adductor impressions, submarginal, posterior, situated about twice their diameter apart at end of broad, slightly diverging shallow grooves running back from anterior adductors. Surface of valve ornamented with very numerous fine, closely-set, subparallel, thread-like, raised lines of equal strength, radiating from umbo and running at right angles to the four sides, with many shorter similar lines of equal strength but of various lengths intercalated. To the four angles of the shell only a few of the radial lines run the whole way from the umbo, the majority curving round on each side to meet the adjacent sides at right angles. A few weak concentric growth-lines present.

DIMENSIONS.

Width at anterior end, 17 mm. ... ... Length, 12·5 mm.
Width at posterior end, 13 mm. ... ... Height, 5·0 mm.

LOCALITY.—Sholeshook Railway Cutting.

HORIZON.—Sholeshook Limestone.

REMARKS.—Only the impression of the exterior of the shell and the cast of the interior of the same valve, both in a somewhat imperfect state, but belonging to the same individual, are known to me. They present characters which differentiate them from other described species. The nearest allied appears to be *Cr. Crofti*, Dav.,[2] but this shell has an anterior depression on the surface, the posterior adductors are placed nearer together, there is an internal ridge on the posterior face of the shell, and the external ornamentation is rather coarser. *Cr. divaricata*, McCoy,[3] is quite distinct.

CRANIA GRAYI, Dav., var. (Pl. XXIII, Fig. 3.)

There is one small specimen of a *Crania* which is almost indistinguishable from *C. Grayi*, Dav.[4] It consists of an upper valve of a subcircular, conical shape, with a non-central elevated umbo situated at about one-third the diameter from the posterior edge. The surface is ornamented with about fifty strong radiating ribs, equidistant, of equal strength, and projecting a little beyond the margin of the shell, with 2–3 much finer shorter ones between.

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[1] Hall & Clarke: Palæont. New York, vol. viii, Brach., pt. 1, 1892, p. 143, pl. iv G, figs. 22–30.

[2] Davidson: Mon. Brit. Foss. Brach., vol. v, Suppl. Silur., p. 215, pl. xvii, figs. 54–56.

[3] Ibid., vol. iii, p. 78, pl. viii, figs. 7–12.

[4] Davidson: Mon. Brit. Foss. Brach., vol. iii, p. 82, pl. viii, figs. 22–24.

DIMENSIONS.

Diameter	4·0 mm.
Height	1·5 mm.

LOCALITY.—Roadside near St. Martin's Cemetery, Haverfordwest.

HORIZON.—Slade Beds.

REMARKS.—*C. Grayi* is, according to Davidson, only found in the Wenlock Limestone. The American Ordovician species *C. Lælia*, Hall,[1] from the Utica and Lorraine groups appears to be allied to the Slade species.

ORTHIS (PLESIOMYS) PORCATA, McCoy, var. nov. *sladensis*.

(Pl. XXIII, Figs. 4–7.)

This species was recorded with a query by Messrs. Marr & Roberts from the Slade Beds. Many fine specimens of a variety of it are included in Mr. Turnbull's collection. The variety is distinct, particularly with regard to its internal characters, and may have to be regarded as specifically different to the typical *O. porcata*.

DESCRIPTION.—Shell biconvex, semi-elliptical, wider than long, broadest at about half its length; hinge-line straight, less than greatest width of shell; cardinal extremities obtusely angular, sides and front rounded. Pedicle valve moderately convex, less so than brachial valve; no medial depression; beak moderate, slightly incurved, not prominent, but rising a little above hinge-line; hinge-area triangular, not very wide, inclined. Brachial valve slightly more convex than opposite valve; beak rather smaller, slightly incurved; area triangular, nearly vertical, of approximately the same size. Interior of pedicle valve with small, elongated-suboval, muscular area, definitely circumscribed, acutely indented in front, about one-fifth the length of the valve; teeth large. Brachial valve with oval cardinal process; low rounded median ridge running forwards for about one-fourth the length of the valve between deep, narrow, elongated muscular scars; crura stout. Surface of valves covered with numerous subequal fine rounded ribs, slightly curved on lateral portions of shell, increasing by bifurcation at about one-fourth their length, and frequently again nearer margin, to about 150–160 round margin. A few strong concentric growth ridges generally present, and a fine concentric striation.

DIMENSIONS.

	I.		II.
Length	22·5 mm.	...	25·0 mm.
Width at hinge-line	22·0 mm.	...	27·0 mm.
Maximum width	28·5 mm.	...	36·0 mm.

LOCALITY.—Roadside near St. Martin's Cemetery, Haverfordwest.

HORIZON.—Slade Beds.

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[1] Hall & Clarke: Palæont. New York, vol. viii, Brach., pt. 1, 1892, pl. iv H, fig. 1.

REMARKS.—In typical examples of *O. porcata,*[1] as well as in the type-specimen, the pedicle valve is flattened, and only convex about the beak and on the lateral portions; there is also a moderate depression down the middle of the valve, and the muscular area is remarkably square. In none of these points does our variety agree with it. The ornamentation of the surface varies much in the species, but ours is not in complete agreement with any figured, though not much stress need be laid on this fact. This new variety may be named *sladensis.*

ORTHIS aff. BOUCHARDI, Dav. (Pl. XXIII, Figs. 8, 9.)

DESCRIPTION.—Shell subquadrate, rounded, a little wider than long, plano-convex; hinge-line straight, a little less than the greatest width. Pedicle valve convex, slightly keeled, rounded; beak high, incurved; hinge-area triangular, large, vertical or steeply inclined. Brachial valve flattened, with deep, broad median sinus of nearly uniform width, deeply sinuating anterior margin; small inconspicuous beak; narrow hinge-area. Interior of pedicle valve with small teeth, and faint muscular impressions. Interior of brachial valve with bilobed cardinal process; stout strong crura; two pairs of adductor impressions, distinct, rather wide apart, with low rounded ridge between them, anterior pair elongated oval, twice as long as posterior pair, which are subcircular. Surface of valves ornamented with about 30 to 40 subangular ribs, mostly simple, but some bifurcating, and with a shorter one intercalated between each pair; usually finely imbricated concentrically.

DIMENSIONS.

Length	6·0 mm.
Width at hinge	7·0 mm.

LOCALITIES AND HORIZONS.—Redhill Beds, Prendergast Place; Slade Beds, near St. Martin's Cemetery, Haverfordwest.

REMARKS.—This small species appears to be allied to or perhaps a variety of the Wenlock species *O. Bouchardi,* Dav.,[2] but the ribs in the latter are fewer and the imbrications coarser.

STROPHOMENA (?) MEDIOCOSTALIS, sp. nov. (Pl. XXIII, Figs. 10, 10*a*, 11.)

DESCRIPTION.—Shell transversely semi-elliptical, about 1½ times to twice as wide as long; cardinal angles acute, more or less alate; hinge-line straight, at greatest width of shell; lateral and anterior margins rounded; concavo-convex, more or less flattened; valves close together. Pedicle valve gently convex, slightly bent down near anterior and lateral margins, flattened towards hinge-line; beak small, acute, not prominent nor rising above hinge-line; hinge-area narrow, triangular, steeply inclined. Brachial valve flattened or slightly concave; beak small, not prominent; hinge-area very narrow.

Interior of pedicle valve with pair of small, divergent, triangular diductor impressions extending about one-fourth the length of the

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[1] Davidson: op. cit., p. 250, pl. xxxi, figs. 12–20; pl. xlvi, fig. 4.

[2] Davidson: op. cit., vol. iii, p. 209, pl. xxvi, figs. 16–23.

valve; teeth small, slender, divergent. Brachial valve with small bifid cardinal process, each arm transversely grooved; dental sockets narrow, diverging at more than right angles; low, short, rounded ridge between faint adductor scars.

Surface of valves ornamented with one conspicuous, single, strong but slender median rib, with 16–20 fine, straight, primary, radiating, raised, thread-like lines on each side, and between each pair 3–5 finer striæ or lines. A few concentric wrinklings occasionally present near cardinal angles. Shell strongly punctate.

DIMENSIONS.

	I.	II.	III.	IV.
Length ...	10·0 ...	10·5 ...	8·0 ...	14·0 mm.
Width ...	19·5 ...	15·0 ...	12·0 ...	16·5 mm.

LOCALITY.—Quarry at Upper Slade.

HORIZON.—Slade Beds.

REMARKS.—The presence of the median rib and character of the surface-ornamentation distinguish this form from *S. compressa*, Sow., from the Llandovery Beds, to which in general shape, contour, and internal features it is closely allied. The variety of *S. compressa* termed *llandeiloensis* by Davidson,[1] from the Llandeilo Flags, has the same points of difference, and in addition possesses larger diductor scars in the pedicle valve. The Llandovery shell appears to belong to the genus *Stropheodonta*, according to Hall & Clarke, judging from the hinge, but the transverse crenulations are not clearly visible in our Slade shell. One of our specimens, probably a young individual, as it is of small size, has much produced lateral wings, but in the majority of examples the cardinal angles are only slightly produced, though always acutely pointed.

STROPHOMENA ANTIQUATA, Sow., var. (Pl. XXIII, Fig. 12.)

The peculiar lobed variety of *S. antiquata*, figured by Davidson[2] from the Wenlock of Dudley, occurs in the Redhill Beds of Prendergast Place, Haverfordwest. In this form the pedicle valve has a broad, deep, rounded sinus down the middle, with an elevated rounded lobe on each side passing gradually into the somewhat flattened ears. The shell is markedly transverse, being nearly twice as wide as long; the hinge-line is at the greatest width of the shell, and the cardinal angles are almost rectangular, or form an angle of about 75°. The diductor muscles in the pedicle valve form a subquadrate or subpentagonal impression about one-third the length of the valve. The Redhill specimens, being in the condition of internal casts, do not show the ornamentation of the surface, but a few concentric wrinkles are traceable in one specimen near the lateral angles. It seems to me a matter of doubt whether this form is not specifically separable from *S. antiquata*, var. *scabrosa*, which also occurs in the Ordovician of the Haverfordwest district. The shape of the shell is utterly different, and the ornamentation as seen in the typical Wenlock examples is completely distinct.

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[1] Davidson: Mon. Silur. Foss. Brach., vol. iii, p. 316, pl. xlvi, figs. 11–14.

[2] Davidson: op. cit., p. 299, pl. xliv, fig. 3.

The dimensions of two Redhill specimens are the following:—

	I.		II.
Length	7·0	...	8·5 mm.
Width	13·0	...	16·0 mm.

PLECTAMBONITES PAPILLOSA, sp. nov. (Pl. XXIII, Figs. 13, 13*a*, 14, 15.)

DESCRIPTION.—Shell small, transverse, broadly semicircular, twice as wide as long; widest at hinge-line; concavo-convex to plano-convex; cardinal angles sharp and angular, but not produced. Pedicle valve weakly convex, flattened laterally; hinge-line straight; beak small, inconspicuous, not rising above hinge-line; hinge-area narrow, inclined, with triangular delthyrium below beak. Brachial valve slightly concave or nearly flat, flattened laterally; beak very small; hinge-area very narrow, linear. Interior of pedicle valve with small, short, divergent, divaricator scars, extending about one-fourth or one-fifth the length of the shell; teeth short, small, diverging, supported by short dental plates. Brachial valve with short crural plates and cardinal process (characters obscure). Interior of both valves very coarsely papillose, the papillæ large, more or less elongated, and radially but irregularly arranged. Surface of valves ornamented with regular, straight, fine radii of equal size, increasing in number by intercalation of secondary rather finer ribs, about two-thirds to three-fourths the length of the primary, to about 60–80 ribs round the margin.

DIMENSIONS (average).

Length	3·0 mm.
Width	6·0 mm.

LOCALITY.—Quarry at Upper Slade.

HORIZON.—Slade Beds.

REMARKS.—This pretty little species occurs in fair abundance at Upper Slade. It is certainly distinct from *P. sericea*, as its internal characters prove. *P. tenuissime-striata* (McCoy) has much finer and less conspicuous striæ on the surface, and the coarse papillæ on the interior seem to be absent. The undetermined species figured by Davidson[1] from Llandeilo appears to bear a considerable resemblance. '*Leptæna*' *Grayæ*, Dav.,[2] and '*Lept.*' *llandeiloensis*, Dav.,[3] have somewhat similar ornamentation, but ours has not a lobed shell like the former, and the interior of the latter is quite distinct. The two valves are frequently attached and open, as is often the case with *P. plicatella*, Ulrich,[4] an allied form from the Utica group of America. There is no trace of cardinal spines in any of our specimens, but the general characters of the shell recall *Chonetes*.

ATRYPA IMBRICATA, Sow. (Pl. XXIII, Fig. 16.)

This species is stated by Davidson[5] to range up from the Bala to the Wenlock Limestone; and our specimens, which come from the Slade Beds near St. Martin's Cemetery, Haverfordwest, show the typical characters. It has been found in the Chair of Kildare Limestone, but apparently has not previously been recorded from the Bala of South Wales. It seems to be in both cases a rare species.

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[1] Davidson: op. cit., vol. iii, p. 330, pl. xlix, fig. 22.

[2] Id., Suppl., vol. v, p. 171, pl. xii, figs. 23–25.

[3] Ibid., p. 171, pl. xii, figs. 26–29.

[4] Hall & Clarke: Palæont. New York, vol. viii, Brach., pt. 1, 1892, pl. XV A, figs. 34, 35.

[5] Op. cit., vol. iii, p. 135, pl. xv, figs. 3–8.

ZYGOSPIRA HICKSI, sp. nov. (Pl. XXIII, Figs. 17–19.)

DESCRIPTION.—Shell subcircular or ovoid, subglobose, biconvex. Pedicle valve larger than brachial, strongly convex, occasionally with faint traces of median fold; beak incurved. Brachial valve less convex; beak small, overlapped by that of pedicle valve; weak median depression sometimes present on surface of valve. Interior of pedicle valve with stout, short teeth widely separated; small transverse ridge from tooth to tooth; elongated, subparallel, muscular impressions extending nearly half the length of valve and broadening slightly anteriorly, with low ridge between them; no dental lamellæ. Interior of brachial valve with hinge-plate, broad, stout, and cleft in middle into two triangular portions; low median rounded ridge dividing paired impressions of adductors. Surface of valves ornamented with 25–30 simple, straight, rounded, radiating ribs of equal size, without bifurcation or intercalation of shorter ribs; regular, fine, concentric striæ present.

DIMENSIONS.

Length	... ...	10 mm.
Width	... ...	9·75–10 mm.

LOCALITIES.—Cuckoo Grove Lane, Haverfordwest; Upper Slade.

HORIZON.—Slade Beds.

REMARKS.—This interesting shell appears to belong to the genus *Zygospira* (or perhaps its subgenus *Catazyga*), for though we are ignorant of much of its internal structure, and have not seen its brachial spires, yet in its shape, ornamentation, and internal characters, so far as they are known to us, it closely resembles members of this genus. *Zygospira* is known in the British Lower Palæozoic by the form referred by Davidson to *Atrypa* (?) *Headi*, var. *anglica*.[1] There does not seem to be any very marked line of separation between *Zygospira* and *Catazyga*, which Schuchert employs as a generic name; Hall,[2] for instance, considers *Z. anticostiensis* to be intermediate between them. The smaller specimens of this Slade shell in our collection are of a more elongated and ovoid shape, but otherwise appear to be identical with the larger subcircular form. *Z. Headi*, var. *anglica*, differs from our species in having more numerous (forty or more) ribs which are also finer, and in having the muscle-scars in the pedicle valve slightly different; and on the whole it seems to belong to another species.

HYATTELLA PENTAGONALIS, Reed (?). (Plate XXIII, Fig. 20.)

The muscular impressions of *H. pentagonalis*[3] are unknown, but

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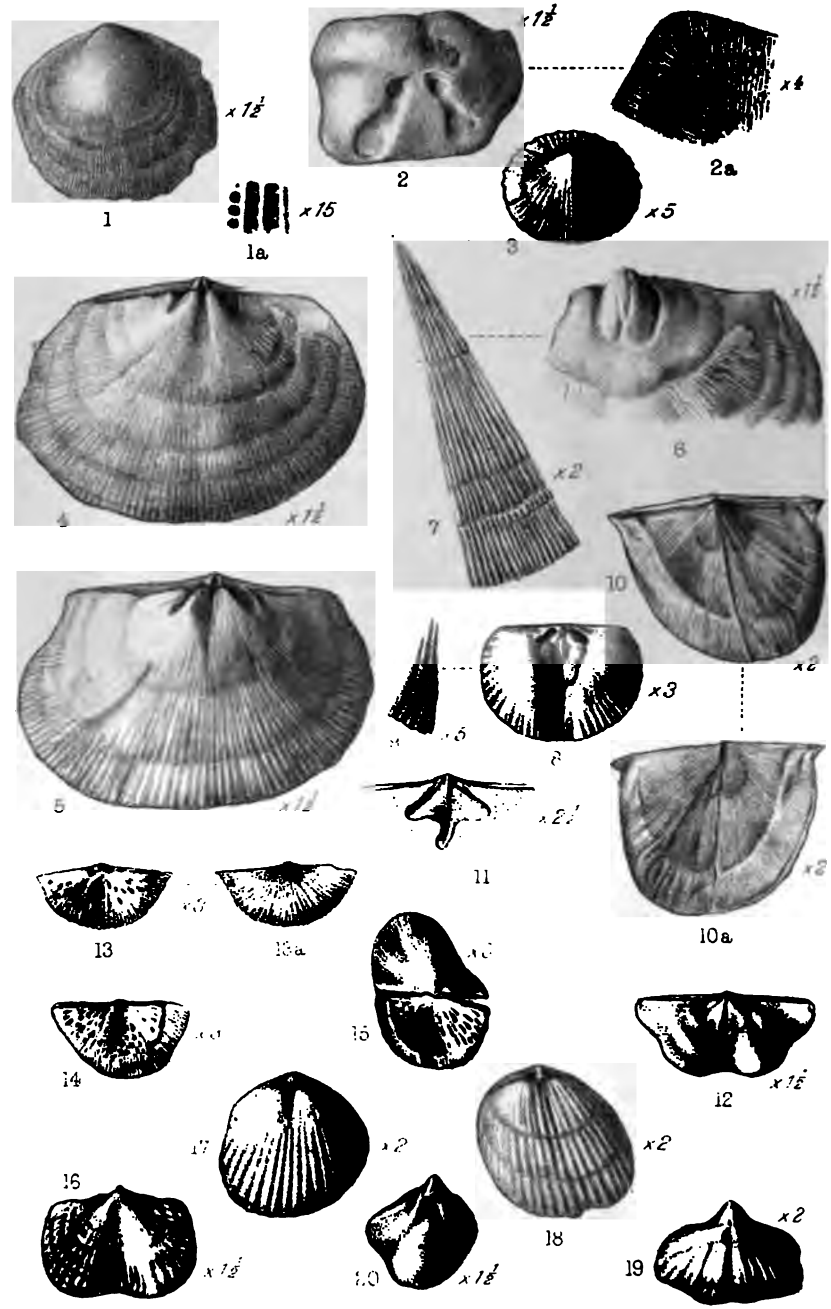
[1] Davidson: op. cit., vol. iii, pl. xxii, figs. 1–8; suppl., vol. v, p. 127.

[2] Hall & Clarke: Palæont. New York, vol. viii, Brach., pt. 2, pp. 154–159.

[3] Reed: Quart. Journ. Geol. Soc., vol. liii (1897), pp. 75–77.



G M Woodward del et lith. West, Newman imp

Ordovician Brachiopoda, from Haverfordwest.

there is an internal cast of the pedicle valve of a shell which in shape and other characters resembles this species, and possesses muscular characters like those of the genus, especially like those of the type-species *H. congesta*, Conr.[1] The pedicle cavity, the subparallel, short dental lamellæ, and a subrhomboidal sharply bounded muscular scar, angularly notched behind, and comprising the two diductors enclosing the narrow contiguous adductors, are clearly seen. The specimen is imperfect, but must have measured about 12 mm. long by 10 mm. wide.

LOCALITY.—Bank Saeson, Whitland.

HORIZON.—Slade Beds.

MERISTELLA cf. CRASSA, Sow.

Several imperfect internal casts and external impressions of a species of *Meristella* occur in the Slade Beds near St. Martin's Cemetery, Haverfordwest. In external form and internal features they agree closely with *M. crassa* (Sow.)[2]; in the pedicle valve we find the dental lamellæ pursuing the same course, and the muscular area and diverging lateral vascular impressions are precisely similar; in the brachial valve the cleft hinge-plate and median longitudinal septum are developed in the same manner. The external shape of the shell and smooth character also agree. *M. crassa* occurs in the Lower Llandovery, and this Slade form may prove to be a separate species or a variety.

EXPLANATION OF PLATE XXIII.

Fig. 1.—*Trematis multistriata*, sp. nov. Brachial valve. Lower Llandeilo Limestone: Lampeter Velfrey. × 1⅓.
,, 1*a*.—Ditto. Portion of surface of same specimen. × 15.
,, 2.—*Crania Turnbulli*, sp. nov. Cast of interior of upper valve. Sholeshook Limestone: Sholeshook railway cutting. × 1⅓.
,, 2*a*.—Ditto. Impression of part of surface of shell of same specimen, showing ornamentation. × 4.
,, 3.—*Crania Grayi*, Dav., var. Slade Beds: near St. Martin's Cemetery, Haverfordwest.
,, 4.—*Orthis* (*Plesiomys*) *porcata*, McCoy, var. nov. *sladensis*. Cast of interior of brachial valve. Slade Beds: near St. Martin's Cemetery, Haverfordwest. × 1⅓.
,, 5.—Ditto. Ditto. Same horizon and locality. × 1⅓.
,, 6.—Ditto. Cast of portion of interior of pedicle valve. Same horizon and locality. × 1¼.
,, 7.—Ditto. Impression of part of surface of shell, showing ribbing. Same horizon and locality. × 2.
,, 8.—*Orthis* aff. *Bouchardi*, Dav. Cast of interior of brachial valve. Redhill Beds: Prendergast Place. × 3.
,, 9.—Ditto. Impression of part of surface, showing ribs. Redhill Beds: roadside near St. Martin's Cemetery. × 5.
,, 10.—*Strophomena* (?) *mediocostalis*, sp. nov. Cast of interior of pedicle valve. Slade Beds: Upper Slade. × 2.
,, 10*a*.—Ditto. Impression of exterior of same valve and specimen. × 2.
,, 11.—Ditto. Cast of interior of anterior part of brachial valve. Same horizon and locality. × 2½.
,, 12.—*Strophomena antiquata*, Sow., var. Cast of interior of pedicle valve. Redhill Beds: Prendergast Place. × 1⅓.

[1] Hall & Clarke: Palæont. New York, vol. viii, Brach., pt. 2, 1894, p. 61, pl. xl, figs. 23–28.

[2] Davidson: op. cit., vol. iii, p. 117, pl. xiii, figs. 1–3.

FIG. 13.—***Plectambonites papillosa***, sp. nov. Exterior of pedicle valve. Slade Beds: Upper Slade. × 3.
„ 13*a*.—Ditto. Cast of interior of same valve and specimen. × 3.
„ 14.—Ditto. Pedicle valve, showing portion as cast. Same horizon and locality. × 3.
„ 15.—Ditto. The two valves in natural juxtaposition. Same horizon and locality. × 3.
„ 16.—***Atrypa imbricata***, Sow. Pedicle valve. Slade Beds: Cuckoo Grove Lane, Haverfordwest. × 1½.
„ 17.—***Zygospira Hicksi***, sp. nov. Cast of interior of brachial valve. Slade Beds: Cuckoo Grove Lane, Haverfordwest. × 2.
„ 18.—Ditto. Cast of interior of brachial valve, showing hinge, etc. Same horizon and locality. × 2.
„ 19.—Ditto. Cast of interior of umbonal portion of pedicle valve, showing teeth, etc. Same horizon and locality. × 2.
„ 20.—***Hyattella pentagonalis***, Reed (?). Cast of interior of pedicle valve. Slade Beds: Bank Saeson, Whitland. × 1½.

IV.—THE RECENT GEOLOGICAL HISTORY OF THE BALTIC. PART III: THE WESTERN PART OF THE SEA, THE SOUND, AND THE BELTS.

BY SIR H. H. HOWORTH, F.R.S., F.G.S.

(*Concluded from the September Number, p.* 413.)

PROCEEDING westward, the fauna again increases in richness. The molluscan fauna of the Gulf of Kiel has been elaborately described by Meyer and Möbius in their well-known work entitled "Fauna der Kieler Bucht." They thus enumerate the shells found there:—

OPISTHOBRANCHIA.

Pontolimax capitatus.
Elysia viridis.
Embletonia Mariæ.
E. pallida.
Æolis alba.
Æ. Drummondii.
Æ. papillosa.
Æ. exigua.
Æ. rufobranchialis.
Dendronotus arborescens.

Polycera ocellata.
P. quadrilineata.
Ancula cristata.
Doris pilosa.
D. proxima.
D. muricata.
Philine aperta.
Acera bullata.
Cylichna truncata.
Amphisphyra hyalina.

PROSOBRANCHIA.

Chiton marginatus.
Tectura testudinalis.
**Litorina litorea.*
L. obtusata.
**L. rudis.*
Lacuna divaricata.
L. pallidula.
**Rissoa inconspicua.*
**R. octona.*
R. striata.

**Hydrobia ulvæ.*
†*Velutina haliotoidea.*
**Cerithium reticulatum.*
†*Triforis perversa.*
Buccinum undatum.
**Nassa reticulata.*
Fusus antiquus.
†*Pleurotoma turricula.*
Odostomia rissoides.

LAMELLIBRANCHIA.

**Mytilus edulis.*
Modiolarca discors.[1]
M. nigra.
M. marmorata.
**Montacuta bidentata.*
**Cardium edule.*
**C. fasciatum.*

Cyprina islandica.
**Astarte borealis.*
†*A. sulcata.*
A. compressa.
**Tellina balthica.*
†*Tellina tenuis.*
**Scrobicularia piperata.*

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[1] In the previous part of this paper, at p. 412, lines 3 and 23 from top, for *Modiolaria* read *Modiolarca*.—H. H. H.

Scrobicularia alba.	†*Saxicava rugosa.*
Solen pellucida.	†*Pholas crispata.*
**Corbula gibba.*	†*P. candida.*
**Mya arenaria.*	*Teredo navalis.*
†*M. truncata.*	

Among these molluscs those marked with an asterisk are common and found in large numbers, while those marked with a dagger are scarce. The remaining species occur sometimes commonly, and are sometimes scarce. Thus say our authors: "When we began our work *Teredo navalis* was common. It then seems to have become extinct, and afterwards began to occur again. *Solen pellucida* became similarly uncommon after being frequently found." They attribute the scarce forms to vagabonds which have made their way from the Cattegat into the Bay of Kiel, especially in the embryo stage, and they mention in addition to such casual visitors among the molluscs certain other vagabond marine animals as taken in August and September, 1861, the Cœlenterates *Bolina alata*, *Melicertum georgicum*, *Steenstrupia rubra*, and a species of *Bourgainvillia*, while in 1869 a species of *Rhizostoma Cuvieri* found its way there (id., xxiii).

Petersen, in addition to the molluscs mentioned by Meyer & Möbius from Kiel harbour, also names *Cardium exiguum*, var. He substitutes *Astarte Walhami* for *Astarte sulcata* as given by M. & M., *Abra alba* for *Scrobicularia alba* of the same writers, and also adds *Scrobicularia plana*, a form unknown to Jeffreys, but as he does not quote *piperata* he possibly treats this as a synonym. Nor does he mention *Tellina tenuis* and *Teredo norvegica*.

In regard to the Gasteropods from Kiel, he substitutes the generic name *Acmæa* for *Tectura*, in which he seems to be wrong (see Jeffreys, iii, 246). He names *Velutina lævigata* and *V. haliotoidea*, both of which are treated as synonyms (ibid., iv, 242), and neither name occurs in the list of M. & M. He apparently substitutes *Bela utricula* for the *Pleurotoma turricula* of M. & M. He properly substitutes the generic name *Utriculus* for those of *Cylichna* and *Amphisphyra* of M. & M., and gives the species *obtusus* while omitting that of *hyalinus*, M. & M., from Kiel, and he adds to the *Rissoas* of M. & M. from the same place the species *membranacea*, *octona*, and *inconspicua*.

Meyer says that his information went to show that virtually the same marine fauna which he described from Kiel also occurs in the harbour of Flensborg, and he only names one additional mollusc thence.

This completes our survey of the Mollusca in the Southern and Western Baltic, and it will be seen how rapidly it becomes richer as we get nearer to the sources of ocean water in the west.

The gradual change in the size of the molluscs which I noticed in the Eastern Baltic as we proceed eastwards is also paralleled in the Western Baltic. Thus *Litorina litorea*, which in the North Sea has a normal length of 32 mm., in the Kiel Gulf only reaches 27 mm., while *Buccinum undatum*, which is normally 120 mm. long in the North Sea, is only 58 mm. at Kiel and 55 mm. at Travemüude. Möbius and Heincke have remarked the same fact in regard to the size of the fish of the Western Baltic compared with those of the North Sea, while their bodies are distorted and the armature of their skins with spines and similar excrescences is more marked. It has also been noticed that the sexual maturity of the animals in these brackish waters arrives earlier than in salt. The stunting of the forms is also true of the worms and Crustaceans, and Braun tells us that the *Aurelia*, the only worm which reaches the Bothnian Gulf, is only 6 mm. in length there. Norquist has noticed that among the Copepods the same stunting takes place, that it is most marked in the females, and that in the matter of the size of the antennae and furca there is a great variety between the individuals of the same species in the Baltic and the North Sea. Brandt expresses himself most emphatically that this stunting and change, which are thus so general, are due to the gradual sweetening of the water as we advance further from the sea.

Having examined the distribution and characteristics of the living fauna of the Western Baltic let us proceed a step further. The Cattegat communicates with the Baltic by three passages, the Sound and the two Belts, and in all three there is a marked enrichment of the molluscan fauna as compared with Kiel. This is largely due, no doubt, to the fact that the narrowness of their channels and the speed of their currents cause the indraft of salt water from the North Sea to be less mixed with the fresh-water outward current than it is in the districts further to the south and east, i.e. in the true Baltic.

The Sound—'Oresund,' as it is known to the Danes—is much the most important of these water conduits, and the only one of whose zoological features, so far as I know, we have a detailed description. This is contained in the monograph by Örsted entitled "De regionibus Marinis," etc., published at Copenhagen in 1845. He describes it as lying between 55° 20′ and 56° 18′ N. lat., and as bounded on the north by a line joining Gilleleje and Kullen, while its southern limit is a similar line joining Stevns and Falsterbo. Its length is 13 miles. Its greatest width, from Copenhagen to Malmö, is four miles, while at its narrowest, between Kronborg and Helsingborg, it is 6,340 cubits ('cubitorum' is the word used). Örsted divides it into three sections. The most northern, extending as far as Helsingor and Helsingborg respectively, is a mere prolongation of the Cattegat. The middle portion extends as far as Copenhagen and Barseback; and the southern one, which is a mere prolongation of the Baltic, extends to the southern limit already named. The middle portion is alone properly called the Sound.

According to Örsted there have been found 427 forms of animals, exclusive of infusoria, in the Sound. These are thus classed:—

Fishes	90	Vermes	110
Crustacea	77	Radiata	58
Arachnida	3	Mollusca...	89

Thus, in the class of Mollusca alone the number of species is considerably greater than that of the Baltic, as measured by the havens of Kiel and Flensborg.

The shells found in the Sound, according to Örsted, are:—

Limnæa balthica.
Paludinella ulvæ.
P. baltica.
P. vulgaris.
Neritina balthica (a var. of *fluviatilis*).
Trochus cinerarius.
Nucula, n.sp.
N. margaritacea.
Leda rostrata.
L. intermedia.
Modiola vulgaris.
M. discrepans.
Litorina litorea.
L. petræa.
L. rudis.
L. retusa.
L. fatalis.
Lacuna quadrifasciata.
L. canalis.
L. pallidula.
Nassa reticulata.
Purpura lapillus.
Cerithium danicum.
Acera bullata.
Bullæa aperta.
Tergipes lacinulatus.
Limapontia nigra.
Velutina capuloides.
Buccinum undatum.
Fusus antiquus.
Fusus sp.
Trophon clathratum.
Cardium echinatum.
Abra tenuis.
A. nitida.
Psammobia faeroensis.
Cryptodon flexuosum.
Tellina depressa.
T. tenuis.
T. balthica.
Astarte damnoniensis.
A. striata.
Lucina radula.
Cyprina islandica.
Venus gallina.

Solen pellucidus.
Hiatella arctica.
Mya truncata.
M. arenaria.
Phalusia intestinalis.
P. tubifera.
Doris tuberculata.
Doris, n.sp. (like *verrucosa*).
D. obvelata.
Polycera quadrilineata.
Defrancia sp.
Rostellaria pespelicani.
Dentalium entale.
Mytilus edulis.
Cardium edule.
Corbula nucleus.
Mactra solida.
Mactra, n.sp.
Pecten opercularis.
P. striatus.
P. septemradiatus.
Anomia squamula.
A. undulata.
A. aculeata.
Anomia, n.sp.
Idalia caudata.
Tritonia velata.
Eolidia papillosa.
Actæon minutum.
Patella pellucida.
P. virginea.
P. tesselata.
Chiton cinereus.
C. ruber.
Ascidia rustica.
Paludinella sp.
,, ,,
,, ,,
,, ,,

Örsted does not give names to these four species, as he had not seen the animal, but only dead shells (id., p. 70). He also refers to three new species of *Ascidia* to which he does not give names (id., p. 74).

The living fauna of the two Belts is not so well known as that of he Sound, but it apparently has the same lesson for us.

Meyer tells us he found in the Little Belt, between the islands of Fänö and Fünen, in half a day's dredging, several species, such as *Doto coronata, Saxicava rugosa, Flustra foliacea,* and *Solaster papporus,* which do not occur in the Baltic, while in a few hours' fishing in the Great Belt he added the following species of marine animals to those occurring in the true Baltic (Meyer & Möbius, i, xix):—

Trochus cinerarius.
Aporrhais pespelicani.
Scalaria communis.
Eulima distorta.
Trophon clathratus.

Leda caudata.
Saxicava rugosa.
Balanus porcatus.
Pomatocerus tricuspis.
Psolus phantopus.

Echinus drobachiensis.
Echinocyamus angulosus.
Amphidetus cordatus.
Ophiopholis aculeata.
Ophiura texturata.
Nonionina crassula.
Bulimina scabra.
Miliolina seminulum.

In addition to the eloquent testimony of these lists it should be remembered that in the Sound certainly, and probably in the Belts, the number of species is larger in their northern than their southern parts. The evidence is, in fact, complete and conclusive that these three conduits are mere outlets of the Cattegat, and their contents, like the contents of marine origin in the Baltic, are colonists from that wide arm of the sea, which migrated at the time of the shattering of the ancient land-bridge, and thus became highways by which the salt water of the Cattegat and a portion of its living contents found their way into the Baltic.

We cannot any longer doubt that the whole of the marine fauna and flora of the Sound, the Belts, and the Baltic are comparatively quite recent immigrants, and that before the breakdown in the bridge just referred to there were none of them to be found south of the northern entrances of the three waterways in question. A parallel case to this breakdown and its consequences is quoted by Reclus, who says:—

"The litoral 'cordon' which bounds the Limfiord on the west has been broken down several times by tempests, notably in 1624, 1720, 1760, and on Nov. 28th, 1825, when terrible inundations overwhelmed the low districts of the North Sea. . . . . The outer beach of the Limfiord, known as the Harboore Tange, was broken down, and the waters of the lake were once more united to the sea by one of the numerous Nymunde (new mouths).

"Before the opening of the breach at Agger all the western part of the Limfiord formed a fresh-water lake, but the intrusion of the sea water and the recommencement of a marine current caused great changes. Multitudes of fish entered it, while the proportion of salinity rose to 18 per thousand, and oyster beds were formed here and there. This new entrance was not used for navigation till 1854, and it was subject to great oscillation, at one time not having more than 1½ metres on the bar and sometimes 3 metres. In 1863 a new mouth was opened at Ron. In 1875 that at Agger was again closed by the sea." ("Nouvelle Géographie," v, 10.)

What it is a little startling to find, however, is that not only have all the marine forms of life in the Baltic and its three inlets migrated thither recently, but actually in the human period and during the so-called Neolithic or second Stone age; and that all the variations, distortions, and stunting of various forms of marine life in the Baltic which differentiate them from the similar forms in the open sea, and which, in this view, become more than ever important and deserving of study, have arisen since man occupied the country.

It seems to me that this fact makes it very important that all the forms of life in the Baltic should be subjected to a newer and closer analysis than they have yet received, with the object of ascertaining how far and in what way the marine fauna of the North Sea has been sophisticated in various ways, quite lately, in order to adapt it to the conditions of brackish water in the Baltic.

Let us now take another step. It will be quite obvious to everybody that when the breakdown in the land-bridge so frequently referred to in these papers took place it was not only the Baltic and its fauna which was certain to be affected, but the Cattegat; only that in the latter case the effect would be the opposite of what it was in the former. The breakdown in question no doubt opened a gate for a great inflow of salt water from the Cattegat, but the same operation opened a corresponding gate by which the fresh waters of the vast *Ancylus* sea flowed into the Cattegat, and in this way reduced their salinity very materially.

Of this we have some very interesting and curious evidence in the extinction of certain molluscs in the southern part of the Cattegat which once lived and thrived there, as we know from the shell mounds and raised beaches and kitchen middens of the northern shores of the Danish islands and the southern shores of the Cattegat itself.

This important induction was first made in 1888 by the Danish conchologist C. G. J. Petersen. He thus compares the fossil and the living shells he had found in the Odense fiord in the island of Fuen ("Om de Skalbærende Mollusken udbredningsforhold i de Danske haven, etc.," p. 50):—

FOSSIL SHELLS.

Odostomia sp.
,, ,,
Utriculus truncatulus.
Hydrobia ulvæ.
Rissoa membranacea.
R. striata, var.
R. inconspicua.
Litorina litorea.
L. rudis.
L. obtusata.
Cerithium reticulatum.
Triforis perversa.
Nassa reticulata.
Anomia squamula.
Ostrea edulis.
Mytilus edulis.
Cardium exiguum (typical).
C. edule.
Macoma (Tellina) balthica.
Scrobicularia plana.
Venus (Tapes) pullastra.
V. (T.) aureus.
Montacuta bidentata.
Mya arenaria.
And in a neighbouring place a valve of *Tapes decussatus.*

LIVING SHELLS.

Utriculus obtusus.
Acera bullata.
Hydrobia ulvæ.
Rissoa membranacea.
R. striata.
Lacuna divaricata.
Litorina litorea.
L. obtusata.
L. rudis.
Cerithium reticulatum.
Nassa reticulata.
Buccinum undatum.
Tectura testudinalis.
Modiolarca discors.
Cardium edule.
C. exiguum, var.
Mytilus edulis.
Macoma (Tellina) balthica.
Abra alba.
A. nitida.
Solen pellucidus.
Mactra subtruncata.
Thracia papyracea.
Corbula gibba.
Saxicava rugosa.
Mya truncata.
M. arenaria.

Petersen was the first to see and to emphasize the importance of these lists, especially when compared with other evidence to be presently referred to. He pointed out that among the molluscs which once evidently flourished in the Odense fiord are some which can no longer live in the southern part of the Cattegat. Among these he specially mentions *Ostrea edulis*, *Cardium exiguum* (the typical form), *Tapes decussatus*, *T. pullastra*, and *T. aureus*.

The oyster, which once apparently lived as far south as the Ekernfiord, no longer lives south of a line from Anholt to the Horsens fiord. On the Swedish coast it does not occur living south of Marstrand. On the Jutland side, while it occurs, but not abundantly, at Skagen, it flourishes in the western part of the Limfiord.

The former occurrence of the oyster in great banks where it must have greatly thrived, where it will no longer live, was further confirmed by the examination of the so-called kitchen middens, which contain an abundance of oysters and whose distribution is very interesting. They are not found in the interior fiords and channels and the belts between the islands, but are almost entirely limited to the shores of the Cattegat and the Limfiord. Thus, writing in 1867, Valdemar Schmidt says that more than a hundred kitchen middens were then known, nearly all of them on the shores of the Cattegat and the Limfiord. The west coast of Jutland and Schleswig have none of these deposits, showing how they have been worn away by the sea. The greater part of those occurring in Zealand are found on the borders of the Roeskilde fiord and the other branches of the Ise Fiord, thus at Kattingevek, at Bregnebierg, at Herlevspynt, at Bilidt, at Gjevningepyut, at Gierdrup, at Soelayer, at Havelse, and quite near to Roeskilde, at the bottom of the fiord at Bierget, at Haraldsborg, at Bogenas, and at Askhoved.

On the Limfiord there is one near the town of Aalborg, on the Signalbakke, which rises 60 metres above the sea-level, others at the Oesterbakker (oyster hills), at Roerdal, Restrup, and Gudumlund.

Further towards the south there is one on the north shore of the Mariagerfiord, another at Visborg, 500 metres long, others at Subaken, Hadsund, Repshaek, etc.; while the south shore of the fiord presents others over an extent of 10 kilometres. We then come to the deposits at Meilgard, at Kolindsund, now a lake, but once an arm of the sea, Kaloe, etc., etc. In the Horsens fiord we meet with a mass of oysters at the bottom of the bay called Norrestrand; at Boller we find remains of mussels and cockles. The Veile fiord presents several deposits, such as that at Bredhalla. The northern coast of Fuen also has its kitchen middens. Schmidt says that sometimes, as at Gudumlund, which is 10 kilometres from the sea, we find such a kitchen midden, but he says in such cases they were planted on an arm of the sea which has been lost by elevation. He says further that in Central and South Denmark kitchen middens were partially inundated by the sea, e.g. one used to exist at Viele.

The presence of the oyster here of full size was long ago commented upon. Thus Lyell says: "*Ostræa edulis* cannot live at present in the brackish waters of the Baltic [he ought to have *said* the Southern Cattegat] except near its entrance, where, whenever a north-west gale prevails, a current setting in from the ocean pours in a great body of salt water. Yet it seems that during the whole time of the accumulation of 'the shell mounds' the oyster flourished in places from which it is now excluded. In like manner the cockle, mussel, and periwinkle, which are met with in great numbers in 'the refuse heaps,' are of the ordinary dimensions which they acquire in the ocean, whereas the same species now living in the adjoining parts of the Baltic only attain a third of their natural size, being stunted and dwarfed in their growth by the quantity of fresh water poured by rivers into that inland sea" ("Antiquity of Man," pp. 13 and 14).

We can hardly doubt that the extinction of the oyster in the southern waters of the Cattegat was due to the same cause which exterminated the *Litorinas*, the *Rissoas*, and the *Scrobicularia piperata* in the Eastern Baltic, which I have described at great length in an earlier paper, namely, the breakdown of the land-bridge, which affected the salinity of the water.

Baer showed that the oyster cannot live in water holding more than 37 parts in a thousand of salt or less than 16 or 17 parts; and it seems plain that when the oysters were living in the Southern Cattegat the waters of the latter, as Petersen urged, and as has been generally conceded, were both salter and warmer.

The oyster is not alone in having had to move further northward, as is attested by the shell-beds and also by the kitchen middens, which contain other edible molluscs. The typical form of *Cardium exiguum* and *Tapes pullastra*, found with the oyster in the raised beds and kitchen middens of the Southern Cattegat, have now withdrawn to the Limfiord, and chiefly to its western part, which is the most salt.

Tapes pullastra still lives on the Swedish side of the Cattegat with its relative *T. aureus*, but not further south than Bohuslan, while *T. decussatus*, the most remarkable of all, which Steenstrup found fossil at Kolindsund and in the Havelse and Mariager fiords (see "Oversigterne over Videnskahemes Selskabs Förhandlungen," p. 188), is not found living now in either of the great fiords, nor in fact south of Bergen in Norway. At Marieburg, Steenstrup also found *Pecten varius* and species of *Parthania* and *Odostomia*, now only living further north, as at Lighed and in the Limfiord.

From the prevalence of several species of *Tapes* in the beds at this horizon Petersen called them the *Tapes* beds. His view that they argued a greater former salinity in the Southern Cattegat has been generally accepted by the Scandinavian zoologists and geologists. De Geer argued that the access of more salt water in ancient times to what is forthcoming now was due to the fact of the Limfiord having been open and there having been a continuous current through it into the Baltic, but I cannot think this can ever have been the controlling cause of such an important change.

What reduces the salinity of the Southern Cattegat is the immense outpouring of brackish water from the Baltic, the result of the vast quantities of fresh-water continually pouring into it from its many rivers, and so long as this outpouring has taken place so long must the salinity of that sea have been greatly lowered. I have no doubt that the migration of the *Tapes* fauna northward was due to the inrush of the fresher water from the Baltic, which first poured out of it in any great quantity when the great Baltic breach occurred.

From this evidence it is plain that the Western Baltic and its three waterways furnish complete confirmation of the conclusion forced upon us by the evidence of the Eastern Baltic, namely, that the land-bridge once separating the Cattegat fiord from the great *Ancylus* sea was broken down in the human period, and, as the western evidence shows, after the period when the kitchen-midden-men lived in Denmark.

The same evidence also points to the breakdown having been rapid or sudden, for, so far as we know, there is no evidence of the gradual dwarfing and distortion of the *oysters* and the *Tapes*, but they went out of existence when in full prosperity, as if the cause of their death and extinction was a catastrophe. We can hardly resist the further conclusion that during the period when the kitchen-midden-men were laying down their refuse heaps, the Baltic was a fresh-water inland sea, and the Cattegat was much salter than now, with a salinity and a zoological and botanical facies very like those of the present Skagerack and North Sea; and that these same men could then pass to and fro over a continuous land-bridge into and from Skäne in South Sweden dryshod, and without any necessity for boats.

ERRATA IN PREVIOUS PAPERS.

Page 316, line 25, *for* at Rördam *read* as Rördam says.

Page 411, line 30, *for* Skalbarende *and* udbredningsfolhold *read* Skalbærende *and* udbredningsforhold.

V.—RODENTS FROM THE PLEISTOCENE OF THE WESTERN MEDITERRANEAN REGION.

By Dr. C. I. FORSYTH MAJOR, F.Z.S.

I. *Geographical Distribution of Prolagus, a Tertiary type of Mouse-Hares (Ogotonidæ), during the Pleistocene.*

IN a former publication[1] I have dealt with the anatomy of *Prolagus sardus* (Wagn.), from the Sardinian and Corsican Pleistocene, in comparison with that of its Tertiary relatives. The following pages deal with the geographical distribution of Pleistocene *Prolagus* and its bearing on more general questions.

When Cuvier discovered, in the ossiferous breccia of Corsica, remains of a '*Lagomys*,' which he believed to be closely related to the Siberian *Lagomys alpinus*, he also suggested other analogies between the faunas of the two regions—Siberia and Corsica (as well as Sardinia), and commented upon the supposed relationship between the insular Mouflon and the Siberian Argali.[2] Similar views were expressed by R. Wagner.[3]

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[1] Forsyth Major, "On Fossil and Recent Lagomorpha": Trans. Linn. Soc. Lond. (2), vol. vii, pp. 433–520 (1899).

[2] "Ossements fossiles," vol. iv, pp. 201, 202 (1823).

[3] *Denkschr. d. Münchner Akademie*, vol. x, p. 783 (1832).

Pumpelly,[1] Locard,[2] and Lortet[3] sought to establish a connection between a supposed Corsican 'ice-age,' as attested by the trace of ancient glaciers, and the former existence in the island of a supposed inhabitant of cold regions, the *Lagomys corsicanus*. Hensel had, however, shown before, in 1856, that the affinities of *Lagomys sardus* from the Sardinian bone breccia are not with the recent *Lagomys* (*Ogotona*), but with a Miocene type, for which he proposed the generic name *Myolagus*[4] (antedated by *Prolagus*, Pomel). He was in consequence inclined to assume a Tertiary age for the breccias in which the *Prolagus* occurred (and, indeed, for the whole of the Mediterranean bone breccias). A similar view has again been brought forward of late years.[5]

I myself pointed out (1) that the Corsican *Lagomys* likewise belonged to the genus *Prolagus*, as indeed had already been suspected by Hensel[6] from his inspection of Cuvier's figures; (2) that the Tertiary age of the Corsican and Sardinian breccias could not be upheld, above all, because the mollusca occurring in them, as Locard had shown to be the case in the ossiferous breccia of Toga, near Bastia, are still living in the neighbourhood.[7]

Not the least interesting feature in the history of insular *Prolagus* is its contemporaneity in Corsica with Neolithic man, of whose food it formed a part.[8] The same observation has been made independently of late years by Monsieur le Capitaine Ferton, who explored some Neolithic stations in the South of Corsica.[9]

The fact that the fauna of the insular breccias proves to be totally different from the contemporary fauna of the surrounding continents[10]—and, so far as the mammalia are concerned, different also from the present fauna of these islands—was the starting-point for my subsequent work on the island life of the Western Mediterranean region.[11] To state briefly one of the principal points: I was led to consider the Sardinian and Corsican Pleistocene faunas as relics of the Tertiary period.

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[1] R. Pumpelly, "Sur quelques traces de glaciers dans l'île de Corse": Bull. Soc. géol. France (2), vol. xvii, p. 81 (1860).

[2] A. Locard, "Note sur les Brèches osseuses des env. de Bastia (Corse)": Arch. Mus. Hist. Nat. Lyon, vol. i, pp. 48, 49 (1872).

[3] Lortet, "Etude sur le Lagomys corsicanus (Cuvier) de Bastia (Corse)": ibid., p. 56.

[4] Zeitschr. deutsch. geol. Ges., vol. viii, pp. 689–703 (1856).

[5] Centralbl. f. Min. Geol. und Pal. No. 18, p. 562 (1902).

[6] Op. cit., p. 696.

[7] Forsyth Major, "Breccie ossifere e stazione neolitica in Corsica": Rend. R. Ist. Lomb. Scienze e Lettere (2), vol. xiii, pp. 432–435 (1880).

[8] Forsyth Major, "Scoperte Paletnologiche in Corsica": Archivio per l'Antropologia e l'Etnologia, vol. x (1880).

[9] Ch. Ferton, "Sur l'Histoire de Bonifacio à l'époque néolithique": Actes Soc. Linn. Bordeaux, vol. liii, pp. 129–147, 347–366 (1898).

[10] Forsyth Major, in Atti Soc. Tosc. Sc. Nat.; Proc. Verb., 9th March, 1879, p. lxxii; id., in Kosmos, vol. vii, p. 6 (1883).

[11] Forsyth Major, "L'Origine della Fauna delle nostre isole": Atti Soc. Tosc. Sc. Nat.; Proc. Verb., vol. iii, pp. 36–42, 113–133, 192 (1881–83). Id., "Die Tyrrhenis. Studien über geogr. Verbreitung von Thieren und Pflanzen im westl. Mittelmeergebiet": Kosmos, vol. vii, pp. 1–17, 81–106 (1883). Id., "Ancora la Tyrrhenis": Atti Soc. Tosc. Sc. Nat.; Proc. Verb., pp. 13–21 (1883).

Professor C. De Stefani, after having strenuously opposed—and distorted—my views,[1] adopted my remarks as his own on the distinctness of the post-Pliocene faunas of those islands. Among his 'novel' observations on the island of Sardinia is the following:—"Le quaternaire est représenté par des grès très récents et par une infinité de brèches osseuses contenant une faune abondante et étrange, tout à fait détachée des formes continentales, de rongeurs, d'insectivores, et même de carnivores d'un type spécial."[2] Thus it has come to pass that in the last two editions of De Lapparent's Manual of Geology[3] the credit for these observations, and for the conclusions drawn from them, is given to the Italian writer, who of all men had done his utmost to discredit these observations and conclusions when they were expressed by myself.

At the time of publication of "Die Tyrrhenis," the most recent continental deposits known to contain remains of *Prolagus* were the lignites of Casino in Tuscany. I therefore looked towards that geological period for a presumed connection of Corsica with continental Europe. "On European soil the *Myolagus* (= *Prolagus*) existed last as a contemporary of the *Hipparion* (Casino); at that period, therefore, there may have still been in existence a connection between Corsica and the Italian Peninsula."[4]

Next came Depéret's discoveries, in the Middle Pliocene of Perpignan (Roussillon), of abundant remains of a *Prolagus*, which the writer considered indistinguishable from the Corsican form.[5] This observation led to his ingenious hypothesis of an isthmus uniting the crystalline formations of Western Corsica with those of the Maures (Southern France); an isthmus which separated two regions of the Pliocene Mediterranean, distinguished from each other by a difference in their respective molluscan faunas. "C'est par cet isthme que les animaux pliocènes du continent ont pu émigrer sur la terre de Corse et s'y perpétuer plus longtemps même que sur le continent, jusque dans les temps pléistocènes. Il n'est par impossible même, étant donné la présence en Corse d'espèces actuelles de mammifères et de l'homme, que cette communication se soit maintenue jusqu'à une époque assez récente."[6]

I had myself hinted[7] at the possibility of a union in the direction advocated by Depéret; I do not see, however, that a connection with Italy in an anterior period is excluded by Depéret's arguments.[8] The Pliocene sea in the region between Corsica and Tuscany, attested *inter alia* by the marine deposits of the island Pianosa, was posterior to the Casino horizon, which coincided with, or followed immediately upon, the period of the maximum of regression of the Mediterranean, a period the marine equivalents of which are not yet known.

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[1] Bull. Soc. Malacol. Ital., vol. ix, pp. 224–230 (1883).

[2] C. De Stefani, "Nouvelles Observations géol. sur l'île de Sardaigne": C. R. Paris, vol. cxiii, p. 607 (1891).

[3] A. de Lapparent, "Traité de Géologie," 3me ed., p. 1540 (1893); 4me ed., pp. 1804, 1805 (1900).

[4] "Die Tyrrhenis . . . . ": Kosmos, vol. vii, p. 106 (1883).

[5] Ch. Depéret, "Les Animaux Pliocènes du Roussillon": Mém. Soc. géol. France; Paléontologie, Mém. No. 3, pp. 56, 122 (1890).

[6] Ch. Depéret, "Étude de quelques gisements nouveaux de Vertébrés Pléistocènes de l'île de Corse": Ann. Soc. Linn. Lyon, vol. xliv, pp. 125, 126 (1897).

[7] Kosmos, vol. vii, p. 105.

[8] *Op. cit.*, pp. 125, 128.

As to the supposed presence in the Corsican Pleistocene fauna of recent mammalian species, I know none, with the exception of the *Cervus corsicanus* and *Ovis musimon*, which last certainly during the Pleistocene was already an inhabitant of Sardinia, and most probably also of Corsica. Depéret gives a list of the species recognised by Cuvier, Lortet, and himself in the "poches à Lagomys" of Corsica[1]; I myself had also given a list from my own collections.[2] Depéret's list includes the following recent species of mammals: *Myoxus glis*, *Mus sylvaticus*, "*Arvicola* groupe d'*amphibius*," *Canis vulpes*, *Ovis musimon*.

The *Ovis musimon* of Lortet's list,[3] "Mouflon, ou probablement une autre espèce semblable," rests on a rib! In Sardinian deposits I found some teeth and an incomplete skull, which I found to agree with *O. musimon*. The *Canis vulpes*, given with doubt in Lortet's list, again rests on 'ribs.'

The vole collected by myself in the Toga breccia, near Bastia, is not an *Arvicola* of the *amphibius* group, but an extinct form, *Arvicola Henseli*, Maj., which frequently occurs in the Sardinian Pleistocene, and of which more will be said hereafter.

The *Mus* found by myself at Toga is not *Mus sylvaticus*, but the extinct '*Mus*' *orthodon*, Hens. My description of this species[4] is partly based on specimens from the Corsican locality, partly on Sardinian specimens (breccia of Bonaria, near Cagliari).

Monsieur Claude Gaillard has most kindly forwarded to me the remains of a *Glis* from Toga, preserved in the Lyons Natural History Museum; they are two left mandibular rami and several bones of the skeleton. There is no doubt that it is the recent species *Glis glis* (=*Myoxus glis*), but it is quite as certain also that these remains have a fresher appearance than those of the *Prolagus*. The difficulty is that, so far as I know, *Glis* has not been mentioned as a member of the recent Corsican fauna; that does not, however, imply that it may not exist in the island.

The fauna of the Corsican breccias, in my opinion, lends support to the hypothesis that the isthmus spoken of may still have subsisted in older Pleistocene times, but certainly not later.

A new aspect of the geographical distribution of *Prolagus* is afforded by the occurrence of this rodent in Pleistocene *continental* deposits. In a recent notice Depéret reports on the discovery, in a cave at Gracia, close to Barcelona, of a Lower Pleistocene fauna, including *Rhinoceros Mercki*, a small form of *Cervus elaphus*, and numerous remains of *Prolagus corsicanus*.[5]

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[1] Op. cit., p. 122.

[2] Kosmos, vol. vii, p. 6 (1883).

[3] Arch. Mus. Hist. Lyon, vol. i, p. 43 (1872).

[4] Atti Soc. Tosc. Sc. Nat.; Proc. Verb., vol. iv, pp. 139–145 (1884).

[5] Ch. Depéret, "Sur l'origine et la dispersion géographique du *Lagomys corsicanus*": C. R. Paris, vol. cxxxv, pp. 884–886 (1902). See also Almera & Bofill y Poch, "Consideraciones sobre los Restos fosiles cuaternarios de la Caverna de Gracia (Barcelona)": Mem. R. Acad. Ciencias y Artes de Barcelona, vol. iv (3), No. 33, pp. 7, 8 (1903).

Gibraltar.—In the "Ossements fossiles" Cuvier reproduces a drawing by Adrian Camper of a specimen from the Gibraltar bone breccia in Camper's collection; the specimen exhibits two mandibular rami of a rodent which Cuvier determined with some doubt as belonging to '*Lagomys*.'[1] Rud. Wagner,[2] as well as Hensel,[3] were even more positive than Cuvier in excluding the genus *Lepus* in favour of *Lagomys*. For myself, I have never doubted that the two rami belong to a species of *Prolagus*, but have refrained from mentioning it, being influenced by the following statement made by George Busk: "We may . . . . in the absence of further information, perhaps be allowed to doubt whether the specimens in question really came from Gibraltar, where certainly in the enormous mass of bones and breccia examined by Dr. Falconer and myself nothing of the kind has turned up."[4] Unfortunately very little has been preserved of the "enormous mass of bones and breccia" brought together chiefly by Captain Brome's exertions and forwarded to the Royal College of Surgeons.[5]

On examining, several years ago, some scanty fragments of bone breccia from the fissure at Rosia Bay, Gibraltar,[6] in the collection of the Geological Society of London, and presented by Mr. James Smith, of Jordan Hill, I discovered in one of them (No. 6) the horizontal section of a molar tooth, exhibiting the characteristic pattern of the anterior lower premolar of *Prolagus*. There is, therefore, no more reason now to doubt of the provenance of Camper's specimens. The dimensions of the tooth—greatest longitudinal diameter = 2·4 mm.; greatest transverse diameter (behind) = 2·3 mm.—agree well with the rather large dimensions of the mandibles figured by Cuvier after A. Camper's drawing.

In the British Museum (Geological Department) is preserved a small bit of stalagmitic breccia, from Gibraltar, according to the information received (the specimen was purchased from a dealer), which contains *inter alia* a right mandibular ramus of a smaller species of *Prolagus*; this I have named (*Prolagus calpensis*, sp.n.),

[1] Oss. foss., vol. iv, p. 174, pl. xiii, fig. 4 (1823).

[2] Op. cit., p. 763.

[3] Op. cit., p. 695.

[4] G. Busk, "On the Ancient or Quaternary Fauna of Gibraltar": Trans. Zool. Soc. Lond., vol. x, p. 58 (1876).

[5] "Some of the brightest records of the military glory and prowess of our country are indissolubly connected with Gibraltar. A great nation like England cannot afford to neglect, or disregard without reproach, whatever bears on the natural history or archæology of so renowned a possession" (Busk & Falconer, in Quart. Journ. Geol. Soc. London, vol. xxi, p. 368, 1865). Meanwhile, we leave it to French geologists to set us right on the geological age of the 'rock' (see Suess, "La Face de la Terre," vol. i, p. 229, footnote 4, 1897; and Lapparent. "Traité de Géologie," 4th ed., p. 1098, 1900), and to a German malacologist to enlighten us on the recent malacological fauna of Gibraltar (see Kobelt, "Studien zur Zoogeographie," vol. ii, pp. 225, 243, 1898). And last, not least, we *throw away* (undeveloped) palæontological collections brought together under exceptionally favourable circumstances by an enthusiastic collector.

[6] "From this fissure ton-loads of mammalian remains were obtained during the scarping of the cliffs, but unfortunately these have long been dispersed" (Ramsay & J. Geikie, in "Geology of Gibraltar," Quart. Journ. Geol. Soc. London, vol. xxxiv, *p. 521*, 1878).

and it is described, and figured in the Catalogue of Fossil Rodentia actually in print.

Cette.—From the ossiferous breccia of Cette (Hérault) Cuvier mentions some scapulæ—one of which is figured—of a small rabbit ('lapin'), of which it is stated, however, that it could scarcely have attained the dimensions of a guinea-pig. Cuvier remarks that very possibly these scapulæ may belong to the same species as the mandibular rami of Gibraltar.[1] This is my opinion also, and I would add besides that two incomplete metatarsal bones from the same breccia, mentioned and figured in the "Ossements fossiles,"[2] likewise belong to *Prolagus.*

Ratonneau.—Continuing our journey eastwards, we next arrive at the ossiferous breccia of the islet Ratonneau, opposite Marseilles, from whence P. Gervais obtained three molars and a lower incisor of a '*Lagomys.*'[3] Considering that in the same breccia was found a species of *Hystrix, H. major,* whose affinities are with Tertiary porcupines,[4] we may fairly assume that the *Lagomys* teeth also belong to the older type of the family, viz. *Prolagus,* rather than to a member of the recent genus.

(According to a statement in Almera & Bofill y Pooh's paper, above quoted,[5] Messrs. Depéret & Deydier have found the *Prolagus corsicanus* in a cave of the valley of the river Durance (Vaucluse). Monsieur Marc Deydier, of Cucuron, however, kindly informs me that this statement rests on a misunderstanding.)

(*To be concluded in our next number.*)

REVIEWS.

I.—MEMOIRS OF THE GEOLOGICAL SURVEY OF GREAT BRITAIN AND IRELAND.

WE regret to find that we are rather behindhand in bringing to the notice of our readers some of the memoirs issued by the Geological Survey; but we can plead, with every hope of pardon, that the publication of our General Index has not unprofitably (so far as our contributors are concerned) occupied our time. Memoirs dealing with parts of England, Wales, Scotland, and Ireland have reached us.

I. ENGLAND.—The Water Supply of Lincolnshire from Underground Sources: with Records of Sinkings and Borings. Edited by Horace B. Woodward, F.R.S., with contributions by William Whitaker, F.R.S., H. Franklin Parsons, M.D., and Henry Preston, F.G.S. pp. 229. (1904. Price 4*s.* 6*d.*)

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[1] Oss. foss., vol. iv, p. 178, pl. xiv, fig. 26 (1823).

[2] Op. cit., vol. iv, p. 178, pl. xiv, fig. 27.

[3] P. Gervais, in C. R. Paris, vol. xlix, p. 511 (1859). Id., Zool. Pal. Gén., vol. i, p. 76 (1867–69).

[4] P. Gervais, opp. citt. Ch. Depéret, "Les Animaux Pliocènes du Roussillon": loc. cit., pp. 43–47 (1890). Id., in Ann. Soc. Linn. Lyon, vol. xliv, p. 125, footnote 2.

[5] Op. cit., p. 7.

This is a continuation of the series of county memoirs on water supply, of which those relating to Sussex and Berkshire have been published.

Records of all known borings and sinkings in Lincolnshire are given, together with numerous analyses of water. In the introduction there is a general account of the geological formations, especially in reference to the water-bearing strata, and a separate article on rainfall, accompanied by a map by Dr. H. R. Mill.

II. WALES.—The Geology of the South Wales Coalfield. Part VI: The Country around Bridgend. By Aubrey Strahan, F.R.S., and T. C. Cantrill, F.G.S., with parts by H. B. Woodward, F.R.S., and R. H. Tiddeman, M.A. pp. 120. (1904. Price 1*s.* 6*d.*)

This is an explanation of Sheets 261 and 262 of the Geological Survey Map (colour-printed), and deals with a bordering portion of the main coalfield of South Wales. The area is largely occupied by the Lower Lias, the Rhætic beds, and the Keuper Marls and Conglomerate—the last-named familiarly known as the Dolomitic Conglomerate. It includes the interesting tracts of littoral Lias at Sutton and Southerndown; also Aberthaw, famed for its lime and cement. A small area of Coal-measures and Millstone Grit and larger areas of Carboniferous Limestone and Old Red Sandstone are described. The hæmatite of Llanharry and the Glacial and post-Glacial deposits are duly noticed.

III. SCOTLAND.—The Geology of West Central Skye, with Soay. By C. T. Clough, M.A., and Alfred Harker, F.R.S. pp. 59. (1904. Price 1*s.*)

This Memoir, descriptive of Sheet 70 of the Geological Map of Scotland, gives a brief account of the Tertiary igneous rocks of the Cuillins, and of the basalt plateaux lying to the north and west of that mountain group. The Torridonian rocks and the Tertiary intrusions occurring in the island of Soay are described. The patches of Triassic, Jurassic, and Cretaceous rocks found on the cliffs on the north side of the Sound of Soay are referred to. Special chapters are devoted to the Glacial and post-Glacial accumulations and to the physical features and scenery.

The Geology of the Country around Blair Atholl, Pitlochry, and Aberfeldy. By G. Barrow, F.G.S., J. S. Grant Wilson, and E. H. Cunningham Craig, B.A., with petrological notes by J. S. Flett, D.Sc. pp. 161. (1905. Price 3*s.*)

This is an explanation of Sheet 55 of the Geological Map of Scotland, the area being entirely within the Highland district of Perthshire. It is one of the most picturesque of the mountain regions, made up mainly of various schists, with the limestones of Loch Tay and Blair Atholl, some grits and quartzites, and the so-called 'Green Beds,' a term not very happily applied to "a series of sedimentary schists, sometimes pebbly, and usually containing a considerable amount of hornblende, chlorite, or epidote." Epidiorite, hornblende schist, and gneiss, and less altered igneous rocks of many kinds, together with sundry glacial drifts, alluvial deposits and peat, make up the table of formations. The memoir is well illustrated by effective pictorial views, but it is stiff reading for the pedestrian, who, rambling along the Pass of Killiecrankie, over the heights of Ben Vrackie, on the shores of Loch Rannoch, or over Carn Mairg, wishes to gather a general notion of what geology teaches.

IV. IRELAND.—The Geology of the Country around Belfast. By G. W. Lamplugh, F.G.S., J. R. Kilroe, A. McHenry, M.R.I.A., H. J. Seymour, B.A., W. B. Wright, B.A., and H. B. Muff, B.A. pp. 166. (1904. Price 3*s.*)

This is an explanation of the special one inch map of Belfast, colour-printed, with Drifts, and it is accompanied by some interesting pictorial views of the Cave Hill quarries (Chalk overlain by basaltic lavas), of the Ordovician rocks on the coast at Carnalea, and other geological features. The account of the Palæozoic and Mesozoic rocks and of the Tertiary volcanic rocks is mainly compiled from previous Survey memoirs and the published works of later observers. The chief work of the Survey was in the detailed mapping of the Drifts, and a very excellent description of these superficial deposits has been drawn up by Mr. Lamplugh and his colleagues. They point out that the chief features are pre-Glacial; the later modifications being mainly due to the partial infilling of some depressions and the carving out of narrow gorges by post-Glacial drainage. During the Glacial episode the whole area was buried under an ice-sheet, and therefore protected from direct subaerial erosion, undergoing only the more partial and probably much less rapid waste from the passage of the slowly moving mass. Water supply, agricultural geology, and other economic matters are dealt with in this Memoir.

II.—BRITISH MUSEUM (NATURAL HISTORY). Guide to an Exhibition of Old Natural History Books, illustrating the Origin and Progress of the Study of Natural History up to the time of Linnæus. Compiled chiefly by B. B. WOODWARD, F.L.S., F.G.S., in charge of the General Library, assisted by the officers of the several departments, etc. (London, 1905: printed by order of the Trustees. Price 3*d.*)

LONG before the discovery of any records of man inscribed or carved on bones, or painted on the walls of caves and rocks, on temples, tombs, or papyri, we may feel quite certain that the earliest representatives of our race had been directed to the open book of Nature, and that plants and animals were the first object-lessons which they studied. Adam, indeed, is credited by his historian with the authorship of the earliest "Index Animalium," but no copy survives. Solomon at a later date is recorded to have been a botanist of wide knowledge, but his learning was oral and traditional and is lost to us.

Both plants and animals appear on Egyptian and Assyrian monuments, and the love of the Egyptians for animals of all sorts, especially for those held sacred to special deities, is well known.

"The ancient Egyptians, however, made no systematic study of Natural History, nor did the early Greek philosophers. Some scattered observations are met with among the writings of the latter, while to PYTHAGORAS [B.C. 569–470] have been attributed ideas concerning the changes in relative level between sea and land that may not improbably be those of later observers. HERODOTUS [B.C. 484 - 406] certainly mentions the occurrence of shells, presumably marine, on the hills of the Nile valley, and deduces from that and other facts the former extension of the sea over the area.[1]

"HIPPOCRATES [B.C. 460–361], the priest-physician and 'Father of Medicine,' mentions the uses of some 240 plants.

"The first person, however, to whom belongs the credit of instituting a genuine study of Natural History was ARISTOTLE [B.C. 384–322], and he has, therefore, been justly called the 'Father of Natural History.'

"His writings on Animals, of which he appears to have known some 500 species, would seem to contain a certain admixture of astronomical symbolism;[2] or else portions belonging to his astronomical writings were by an error of his first transcribers incorporated with those on animals, and this, considering the conditions under which his MSS. had been preserved, would not be remarkable. . . . . He divided animals into *Enæma*, or those having (red) blood, and *Anæma*, or those without, and subdivided the former, or VERTEBRATA, into: Vivipara, Birds, the other Ovipara and Fish; while the latter, or INVERTEBRATA, were subdivided into: Malakia, Malakostraca, Entoma, and Ostrakoderma. The insects (Entoma) he yet further subdivided, and three of his groups, Coleoptera, Psychæ [= Lepidoptera], and Diptera, hold good at the present day! . . . .

"In botany and mineralogy little was done by Aristotle and nothing in geology as now understood, although it is interesting to note in passing that he maintained the earth to be a spherical body, while he was acquainted with the occurrence of fossils in the rocks, and discussed the changes on the earth's surface necessary to account for them.

"It was Aristotle's favourite pupil THEOPHRASTUS [B.C. 371-286], to whom he bequeathed his MSS., who took up the subjects of botany and mineralogy. Minerals were at that time classified into 'metals' and 'stones,' and only his treatise on stones has survived; it is chiefly interesting as showing what characters were made use of at that time for the discrimination of minerals and the description of the species, as well as a record of the places of their occurrence.

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[1] Lyell in his "Principles" does not seem to have read Herodotus' statement quite correctly.

[2] See paper by D'Arcy Thompson, "On Bird and Beast in Ancient Symbolism"; Trans. Roy. Soc. Edinburgh, vol. xxxviii, p. 179.

"After many vicissitudes, which included burial in a catacomb, the remains of the combined MSS. of Aristotle and Theophrastus passed into the hands of Apellicon of Teos [-B.C. 85], who attempted their restoration and had them copied. The transcripts were afterwards seized by Sylla and conveyed to Rome, where they were subsequently edited and given to the world by Andronicus of Rhodes; but their real publication dates from 1495, when they were first printed in the original Greek by the celebrated Venetian printer Aldus Manutius. A Latin translation by T. Gaza of Theophrastus' *De historia et causis Plantarum* had, however, been printed at Treviso in 1483.

"Geology, or more strictly speaking, physical geography, first received serious attention at the hands of STRABO [B.C. 63?–A.D. 24], who originated the theory of the alterations of the level of the land in relation to the sea, in contradistinction to the former belief in the changes of the sea-level.[1] His *Geographicon*, which was written in the early years of the Christian Era, was printed, from the Latin translation, at Venice in 1472 by Vindelinus de Spira, and appeared in the original Greek in 1516 from the press of Aldus Manutius.

"The oldest popular natural history book, and almost encyclopædia, was the *Historia Naturalis*, also termed the *Historia Mundi*, of PLINY THE ELDER [A.D. 23–79]. This voluminous treatise in thirty-seven books has been preserved, and presents an epitome of the state of Roman knowledge on the subject. The number of known plants had by this time increased to about one thousand, and the belief in the existence of sexes in plants had become established; while in the minerals the 'earths' had been made into a class apart from 'metals' and 'stones.' It was probably the earliest work on natural history to be printed, the editio princeps emanating from J. de Spira's press at Venice in 1469.

"The next most important work was the celebrated *Materia Medica* of DIOSCORIDES [A.D. 40?-]. This was a standard book for over a century, and was the basis for most of the early herbals.

"It was first printed at Medemblik, Holland, in 1478, from a Latin translation, made by Hermolaus Barbarus. The Greek editio princeps, from the press of Aldus Manutius, at Venice, appeared in 1499. The work became the subject of much discussion, and of many Commentaries by early botanists of the Renaissance, especially P. A. MATTIOLI [1500–1577] and his contemporaries, who, ignorant of the differences between the floras of East and West Europe, were led into endless difficulties in their attempts to identify their plants from the imperfect definitions of Dioscorides.

"The three Greek writers, Hippocrates, Theophrastus, and Dioscorides, are the authorities for all the Greek names of plants up to the Christian era.

"With the epoch of Pliny and Dioscorides the classical period of natural history may be said to have been brought to a close: the works of the older writers became less studied in Europe, and commonplace books like those of Ælian of Praeneste, a compiler who lived in the third century, were much used. In these, scraps of folklore, travellers' tales and fragments of misapprehended science were set forth in the elegant style then affected. An edition of Ælian's collected works was issued by Gesner in 1556, and a good edition of his *De Natura Animalium* was brought out in 1774 under the editorship of Abraham Gronovius.

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[1] It is most probable that Ovid derived orally from Strabo the ideas which he attributes to Pythagoras in the oft-quoted passages from his "Metamorphoses."

"The early Christian writers, none too conversant with natural history, utilized these works, without question as to their reliability, in their allegorical interpretations of Biblical texts. Hence arose a series of collections, in many languages, of some fifty Christian allegories, much read and quoted in the Middle Ages, known by the common title of the *Physiologus*, or, since most of its imagery was borrowed from the animal world, the *Bestiary*.

"On such productions as these were based the natural history writings of the Middle Ages — 'dark' indeed as regards progress in scientific learning.

"Among mediæval European writers the following deserve notice: — ALBERTUS (Albert von Bollstädt), called ALBERTUS MAGNUS [1193–1280], a Dominican, and sometime Bishop of Ratisbon, who, among his numerous writings, included commentaries on Aristotle and treatises:—*De Animalibus*, first printed in 1479, *De Mineralibus*, printed 1495, and *Tabula tractatuum parvorum naturalium* (in which were comprised his *De Vegetabilibus et Plantis*), printed in 1517.

"VINCENTIUS BELOVACENSIS, or VINCENT OF BEAUVAIS [*c.* 1190–*c.* 1264], another learned Dominican, who resided at the court of Louis IX of France, compiled at the instance of that king a *Bibliotheca Mundi*, which is not only one of the earliest of encyclopædias, but the greatest of the Middle Ages. The first part, entitled *Speculum Naturale*, written about 1250, contains thirty-three books. It was first printed at Strasburg about 1473.

"BARTHOLOMÆUS (Bartholomew de Glanville), called BARTHOLOMÆUS ANGLICUS [fl. 1230–1250], a Minorite Friar, compiled an encyclopædia entitled: *De Proprietatibus Rerum*, which as a manuscript was known in Italy in 1283 and in England in 1296. It was first printed at Basle about 1470, and was the source of common information on natural history during the Middle Ages.

"These authors were followed after a long interval by :—

"LEONARDO DA VINCI [1452–1519], who was not only a great painter, but had also vast knowledge, among other subjects, of anatomy, botany, and geology. He vigorously maintained that the contents of the rocks were real shells, and supported the belief in the changes of sea and land which this view implied. His writings on these subjects were not printed from the original manuscripts till 1881 and 1883.

"GIROLAMO FRACASTORO [1483–1553] declared his opinion that fossil shells had all belonged to animals which had lived and multiplied in the places where their exuviæ are now found, but he was not listened to."

Did space admit we might pursue the description of this interesting exhibition of "Old Masters," but anyone for a modest threepence may acquire a very carefully prepared introduction to a most remarkable series of works by early authors, some of whose writings and accompanying illustrations will well repay a visit to that most attractive Natural History Museum in Cromwell Road, which has now become one of the most valuable teaching-centres in London, and whose library is also one of the best extant, a result largely due to the energy and ability of its Librarian, Mr. B. B. Woodward, to whom we are also indebted for the present exhibition of old Natural History books and for one of the best Library Catalogues (still in progress) which has ever been printed of works bearing on Natural History.

REPORTS AND PROCEEDINGS.

British Association for the Advancement of Science. Cape Town, South Africa, August 16th, 1905.

Address to the Geological Section (C) by Professor H. A. Miers, M.A., D.Sc., F.R.S., President of the Section.

(Continued from the September Number, p. 429.)

Doelter's Work on Melting-Points and Solubilities.

THE labours of Doelter and his pupils have been largely devoted to the melting-points of the rock-forming minerals and their solubility in silicate magmas. From experiments upon these minerals and their mixtures they have come to the conclusion that in many cases the melting-point of the mixture is about the mean of the melting-points of the constituents, and that in such cases, therefore, there is no evidence that the freezing-point is lowered, or that an eutectic mixture is formed; so that it is not safe to apply the theory of cyro-hydrates to fused mixtures of silicates.

Doelter is therefore led to regard the silicate magmas rather as mixtures of various constituents which may be dissolved in each other, but which are not by any means necessarily identical with the minerals which separate on cooling. The whole process seems to him to be far too complicated to be explained by any such simple principle as the mere relative proportions of the various constituents to each other and to their eutectic mixture; the order of crystallisation must be determined by a number of factors, such as temperature, velocity of crystallisation, the interval between the softening and fusing of each mineral (which he finds to be considerable), viscosity, capillarity, the presence of water and mineralising agents, and the absorption of adjacent rocks.

To choose a simple example: minerals such as zircon, corundum, and titanite separate for the most part early, because they are less soluble. On the other hand, magnetite is one of the more soluble minerals, and yet it is one of the first to separate; the same is to a certain extent true of augite, but not always. It is possible that in a magma which still contains the iron of the magnetite in solution plagioclase and augite may be comparatively soluble and magnetite comparatively insoluble, but that when magnetite has already crystallised out from the magma the plagioclase and augite may be comparatively insoluble; the experiments which are wanted are experiments upon the solubility of certain minerals in magmas of known composition under known conditions; in these and similar instances the order of separation is that of the solubility, but such physical factors as the velocity of crystallisation (which varies very considerably with the temperature), and the viscosity, may completely invert the order.

Direct experiments made by Barus and Iddings upon the electric conductivity of silicate magmas afford evidence that such magmas contain dissociated as well as undissociated molecules, so that they cannot be regarded as merely fused mixtures of certain minerals. If two or more rock-forming minerals be fused together it may happen that they form new compounds and crystallise out as different minerals, or if one or the other remains unchanged it may crystallise out in a different proportion. All this shows that double decomposition goes on in the liquid. We cannot therefore expect, without knowing the degree of dissociation, to make such use of the lowering of the freezing-point in order to calculate the other factors in the process of rock-formation.

Doelter concludes that upon the whole the normal order of crystallisation in rocks is in the main that laid down by Rosenbusch long ago, namely, an order of increasing acidity, but that it is determined by the mutual affinities of the molecules in the magma, and by the relative power of crystallisation of the components into which they unite themselves, and that the physical factors which I have already enumerated play a very important part in the process. No one has endeavoured more systematically than Doelter to determine for the rock-forming minerals the melting-points and the solubilities, without which it is impossible to make much progress in our reconstruction of the history of rocks. He has recently shown us how the microscope may be used in the study of fused silicates at high temperatures, and has so opened up a new field of research.

Vogt's Applications of the Laws of Solutions.

The work of Vogt has extended over many years, and is now summarised in two remarkable memoirs recently published by him, in which are expressed his mature opinions upon silicate magmas: the reasoning is based upon his own experiments, upon those of Doelter, and upon the classic researches of Ebelmen. It is now generally conceded that the particular minerals produced in a silicate magma depend much more upon the chemical composition of the magma than upon temperature and pressure; Lagorio and Morozewicz were led to this conclusion by their own experiments upon fused silicates. Experiments upon slags at ordinary temperatures and pressures may, therefore, be invoked to elucidate the formation of rocks.

In 1902 Vogt stated his conviction that the laws of solutions may be applied to igneous rocks, and his two recent memoirs are, in fact, an attempt to explain the experiments upon slags and fused silicates as examples of the operation of these laws.

All-important, according to him, is the composition of the eutectic mixture; he finds that if the analyses of silicate magmas be arranged according to their oxygen ratio or acidity, the various minerals of which they consist make their appearance within fairly well-defined limits. For example, in the case of the Ca Mg Fe Mn slags, which contain little alumina, olivine and the melilite minerals only make their appearance in the more basic slags, and the metasilicates in the more acid, the limit between the two corresponding to an acidity of about 1·6.

The limit of individualisation between the various minerals is supposed to correspond to their eutectic mixture. Such slags may, therefore, be regarded as a mutual solution of two or more of the minerals olivine, enstatite, hypersthene, augite, the gehlenite-melilite group, akermanite, wollastonite, and the hexagonal metasilicate, which is so characteristic of the more acid slags. The particular minerals which make their appearance are practically determined by the acidity of the magma and by the relative proportion of the bases present, particularly by the ratio of the calcium to the magnesium-iron-manganese group; in other words, Vogt asserts that a silicate magma is a mutual solution of the various crystalline compounds that actually make their appearance as it solidifies, and that the order of crystallisation depends upon their proportion in the magma as compared with their proportion in the eutectic. The old conception of a solvent and a solute ceases to have much meaning; the matter which is of supreme importance is the nature of the eutectic mixture when the constituents are given; thus micropegmatite and microfelsite represent the eutectic of felspar and quartz, and correspond to a mixture of about 74 parts of felspar to 26 of quartz, as indeed has been stated by Teall.

Now, if we are justified in regarding rock-magmas and fused silicates as mutual solutions of certain definite compounds, and if these compounds are actual minerals or other silicates which crystallise out of the magma when it cools, we are also justified in making use of the properties of these minerals when we apply to the magma the known physico-chemical laws which govern solutions.

The number and nature of the minerals which can be in equilibrium with each other and the solution are to be determined by experiments upon their solubility interpreted by the phase-rule of Willard Gibbs, and especially by the laws which Roozeboom and other physical chemists have deduced for components which form double salts or isomorphous mixtures. Knowing the components, we ought, therefore, to be able to determine their latent heat of fusion, their specific heat, the lowering of the freezing-point of their mixtures, and from these data to calculate the true formulæ of the rock-forming minerals. It will readily be understood that in a mixture of quartz and orthoclase, the lowering of the freezing-point below that of either of the constituents, as calculated by Van 't Hoff's formula, from their melting-points, latent heats, and molecular weights, will be very different according as the formula of quartz is taken to be SiO_2 or Si_3O_6.

Vogt boldly attacks the whole problem as one that can be solved on these lines: we have good reason to believe that the slags and rock-magmas are solutions; we know their constituents; we can therefore proceed to experiment with these constituents and to predict the behaviour of their mixture according to the principles of physical chemistry. The order of crystallisation is mainly determined by the relative composition of the magma and the eutectic, and the composition of the eutectic may be calculated from the intersection of the freezing-curves.

One interesting result is the conclusion that in the silicate magmas which have been the subject of experiment the minerals produced are all of very simple constitution; that, for example, olivine, diopside, akermanite, melilite, and anorthite have the simplest possible formulæ corresponding to their analyses, and are not polymerised. Mineralogists will welcome this conclusion if it be true, for it has occasionally been the fashion on theoretical grounds to attribute a high degree of polymerisation to many minerals, and nothing is easier than to account for many difficulties if one may multiply the formula of a mineral by any number that is required. It should be added, however, that Doelter, calculating from his own experiments, is led to think that some of the minerals must have formulæ which are multiples of their empirical formulæ.

Vogt even goes a step further in his application of the principles of modern chemistry. The order of crystallisation appears to be by no means always that of the solubility, but indicates that a mineral is sometimes not so soluble as might be supposed. Now another principle in the modern physics of solutions is that by adding to a solution of one substance a new electrolyte containing an ion common to both the solubility of the first is diminished, and Vogt does not hesitate to apply this principle.

Thus spinel and felspar in mutual solution, when felspar is in large excess, should on cooling yield felspar first. But in many basic rocks spinel is the first to crystallise; this is, according to Vogt, due to the presence of ferro-magnesian silicates containing the Mg ion which is also present in spinel; if these be partially dissociated the solubility of the aluminate will be lowered.

An obvious criticism on this argument is that if the dissociation is so slight that it may be ignored for one purpose, it is hardly fair to invoke its powerful action for another, and it is possible that Vogt in his enthusiasm for a theory attempts to explain too much by its aid.

It is clear, however, that the labours of Vogt have been precisely in the direction indicated by Teall in the words that I have quoted, "experiment controlled by the modern theory of solution"; and if his opponents are tempted to think that he may have carried the principle too far with insufficient data, they cannot but admire the brilliancy, the persistency, and the ingenuity with which he has applied the newer theories of solution at every turn.

Heycock and Neville's Work on Alloys.

I must next refer briefly to another remarkable series of researches which have recently been published.

The laws which govern the solutions of metals in metals, that is to say alloys, appear to be the same as those which prevail in the case of other solutions; it is in alloys that the nature of eutectic mixtures has been most fully studied; and the phase-rule and Roozeboom's deductions from it have been applied with signal success to their investigation. A new impulse has been given to the subject by the work of Heycock and Neville, which is summarised in their Bakerian lecture delivered last year upon the copper-tin series of alloys. They have studied the changes which occur during the cooling of an alloy by taking small ingots of the cooling metal and chilling them at certain temperatures; this arrests the gradual process of cooling, and causes all that is liquid at the moment of chilling to become suddenly solid; it is then possible by polishing and etching the ingot to show the solid crystals set in the congealed ground-mass and to study their nature. They have been able to interpret their results by means of Roozeboom's remarkable work on the solidification of mixed crystals published in 1899. For our present purpose it is sufficient to consider these results as applied only to alloys. If a diagram be constructed with the temperatures for ordinates and constitution for abscissæ, Roozeboom has shown that two curves may be drawn. The first is the freezing-point curve, or *liquidus*, giving the temperatures at which an alloy of any composition begins to solidify: this is a broken curve, and each section of it represents the temperature of equilibrium between the liquid and a different solid alloy; the breaks represent the temperatures and constitution of the liquid at which one solid ceases to be produced and another begins. The curve is, of course, far more complicated than the simple V of Meyerhoffer, since that represents the cooling of a mixture whose constituents do not form compounds or isomorphous mixtures, whereas the alloys do both. In this respect the alloys resemble a silicate magma which is crystallising as a rock-mass; indeed, it will be remembered that Mendeléef insists upon the general similarity of silicon compounds to metallic alloys.

The second curve of Roozeboom is the melting-point curve, or *solidus*, representing the temperatures at which an alloy of given composition becomes completely solid. Points above the liquidus represent the condition of alloys which are completely liquid; points below the solidus that of alloys which are completely solid; points between the two that of cooling alloys which are only partially solid; and the curves themselves show which solid compounds can be in equilibrium with the liquid and with each other at any temperature.

The cooling-curves of Roberts-Austen and Stansfield had shown that considerable evolutions of heat may occur in cooling alloys far below the temperature of solidification, indicating that changes are going on in the solid as well as in the liquid condition. Heycock and Neville carry their investigations below the temperature of complete solidification and study these changes also.

In the case of the copper-tin series of alloys they find that, according to the temperature and constitution of the liquid, crystals belonging to no less than six different types may separate, namely:—

α, a solid solution of Cu with less than 9 per cent. of Sn.
β, a solid solution of Cu with less than 27 per cent. of Sn.
γ, of which the constitution is not known.
δ, which probably has the composition Cu_4Sn.
η, which probably has the composition Cu_3Sn.
H, which probably has the composition CuSn.

Both β and γ are unstable at ordinary temperatures. The compound δ crystallises out of β or γ while they are already in the solid state, when the temperature falls sufficiently.

A glance through the 101 photographs of chilled and etched ingots which accompany Heycock and Neville's paper on this series of alloys shows how impossible it would be from the final composition of the solid alloy to ascertain the various stages through which it has passed during cooling; as the authors remark, it is of the nature of a palimpsest. For example, the alloy, containing 14 atoms of tin to 86 of copper, consists at 800° of α crystals in a ground-mass which probably contains β; it solidifies at about 775°; at 675° there are only β crystals; at 600° there are α and β crystals, but here α has crystallised out of β after it became solid; at 530° there is a much larger proportion of α; at 470° there are α crystals immersed in a mixture of α and δ into which the residual β has broken up on cooling.

If the course of events is so complex in an alloy of only two metals, how much more difficult must it be to decipher in the case of a mass of complicated silicates which are even more prone to form isomorphous mixtures, such as we have in a solid rock, not to mention the additional presence of aluminates, oxides, and sulphides. And yet geologists are accustomed to speculate freely about the crystallisation of rock constituents from the magma without taking account of anything save the final stage.

I cannot help thinking that the experimental method of Heycock and Neville will have to be applied to the study of slags and fused silicates if we are to trace successfully the evolution of rock species. The value of their work to geologists is not only that the results are skilfully interpreted by the light of modern physical chemistry, but primarily that it is experimental work upon actual crystallising materials.

(*To be concluded in our next number.*)

CORRESPONDENCE.

THE CHALK BLUFFS AT TRIMINGHAM.

Sir,—Students of East Anglian geology will read with some surprise, in the concluding paragraph of the paper by Professor Bonney and Mr. Hill on the Trimingham Chalk Bluffs, that a hypothetical interpretation of these masses was out of place in a Survey memoir. Surely in a work dealing with this district some attempt was demanded to account for phenomena which "have for many years attracted the attention of geologists" and now, even of the above-named authors themselves, albeit if with the knowledge then (1882) available an exact explanation was not possible.

Nor can it be said that Professor Bonney and Mr. Hill by their communication have advanced matters much, for unfortunately they appear to have left out of sight two rather important items, viz., the fossil contents of the beds and the literature on the subject since 1882.

Long familiarity with rocks which can only be studied stratigraphically and by aid of the microscope and field-glass may, perhaps, have led them to overlook the palæontological aspect of the Trimingham chalk masses. Professor Bonney, it is true, noticed the conspicuous Belemnite occurring throughout, but is not aware that it is of less importance as a zonal guide than the concomitant *Ostrea*, which does not occur throughout.

To thoroughly investigate the fossil fauna of a bed in cases such as the present one is not possible, however, to the casual visitant: it can only be done with long and patient research by one on the spot.

Fortunately the Trimingham chalk masses have had their historian in Mr. R. M. Brydone, who, with a care and patience that cannot be too highly commended, made a thorough examination of them, collected and worked out their fossils, and in 1900 published a pamphlet entitled "The Stratigraphy and Fauna of the Trimingham Chalk." In this he showed that the uppermost portions of the masses are the sole remaining vestiges in England of the Maestrichtian beds of the Chalk. He further discussed Mr. Clement Reid's theory, which in the light of these later researches he showed to be untenable and suggested that these masses were really buried sea-stacks. This view is supported by the Mundesley boring. Whether these pinnacles have remained upright, or have been crushed, crumpled, and overturned, is of little moment, but it is important to note that the strata in them are of the same age as the beds capping the *mucronata* chalk, that are exposed in the beach at extreme low water.

That these masses are part and parcel of the main Chalk strata that lie at no great depth under the beach at this spot, I was enabled to see in the Autumn of 1901 after a storm that had cleared away the beach for some distance round their base. The bands of flint were distinctly traceable down into and right across the exposed surface. The sketch and notes I made at the time were passed on to Dr. Rowe and Mr. Sherborn against the time when they come to deal with the Norfolk district. B. B. Woodward.

4, Longfield Road, Ealing, W.

[We have received several other letters on this subject, all embodying the same points of criticism.—Edit. Geol. Mag.]

THE RAISED BEACHES OF DEVONSHIRE AND OF THE SOUTH OF IRELAND.

Sir,—I much regret to find that I have both misunderstood and misinterpreted Mr. Muff's ice-scored beach-platform in the South of Ireland.

Ever since Godwin-Austen in 1851 attacked the problem of the

Head, Aerial beds, or Rubble-drift, of the south-west of England, geologists have entertained the idea that both the beach-platforms and the beach-deposits may have been influenced by coast ice.

When Messrs. Wright and Muff recorded the fact that a beach-platform in Ireland was scored by ice, nearly parallel with the shore, it never occurred to me that the agent could have been any other than the coast ice so long postulated by the students of raised beaches. Further, I accepted what I supposed to be Mr. Muff's proofs, in spite of my previous contention that the South Devon beach-platforms were not due to coast ice. My paper on the Raised Beaches of Torbay (Trans. Dev. Assoc., 1903) was written to contest Mr. Pidgeon's conclusions as to the Torbay beaches being accumulated under semi-Arctic conditions, and their shells broken by ice.

Ever since Mr. Muff's paper appeared, I have been trying to reconcile his supposed (by myself) glacial ice-scratched platform with the Devonshire evidence, that is to say, a platform contemporaneous with the ice-scorings. I have found it difficult. I am profoundly grateful to Mr. Muff for his prompt and public correction of my mistake.

With regard to the Devonshire erratics, I may say that on the 17th of August last I spent four hours on the Prawle coast, before and after the lowest tide for that full moon. The two crystalline blocks recorded by Pengelly some thirty years ago as on the strand, have been since described as on the beach-platform. They lie just beyond the reach of ordinary spring tides in calm weather, and are certainly on the present tidal strand. When Pengelly described them, the only known explanations of their presence were: wreck, or ice. They are far too heavy and unmanageable for use as ballast, so the only explanation was ice. It was not then known that fishermen often trawl blocks of the size of those referred to, and bring them away from the fishing-grounds. Now, were a fishing-smack, carrying two blocks, to be cast away on the Prawle coast in a S.S.E. gale at the top of high-water spring tides, she might just possibly reach the spot where the two Prawle blocks lie close together. Taking all the facts into consideration, this explanation seems to be the least improbable of the three, viz., ice, ordinary wreck, or trawler wreck.

The ten-ton boulder at Baggy Point in North Devon is obviously nothing but an ice-borne erratic, and the puzzle is that it is apparently associated with such a decidedly southern shell as *Cardium papillosum.* Then at Fistral Bay, in a beach presumably contemporaneous with the Baggy Point Raised Beach, we have *Cytherea chione* recorded; and in Torbay *Fusus Jeffreysianus,* associated with *Trophon truncatus.* It is this association of shells having a northern range with others with a southern range, and the association of a still more decided southern shell with an ice-borne erratic, which is so perplexing.

I do not propose to trespass on your space with any speculations on the subject. So far as Devonshire is concerned, the problem of the beaches may be treated as a strictly local one, and as such better discussed in provincial publications. A. R. HUNT.

FOXWORTHY, MORETONHAMPSTEAD.
9th September, 1905.

THE

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ORIGINAL ARTICLES.

I.—Notes on some New Crocodilia from the Eocene of Egypt.

By C. W. Andrews, D.Sc., F.G.S., British Museum (Natural History).

DURING the last few years a considerable number of Crocodilian remains have been collected from the Middle and Upper Eocene beds of the Fayûm, most of these specimens having been obtained by Mr. H. J. L. Beadnell in the course of his excavations in that locality. This material has recently been examined and determined, and it is found that several new species belonging to the genera *Crocodilus* and *Tomistoma* are represented by more or less complete remains. In the present note it is proposed to give a preliminary account of these new forms, which will be fully described and figured in the Catalogue of the Tertiary Vertebrata of the Fayûm now in course of preparation.

The species of *Crocodilus* now described belong both to the broad- and narrow-snouted divisions of that genus.

Crocodilus articeps, n.sp.

Of the latter group only one species has been found; this is represented by an extremely well-preserved skull wanting the posterior region. This skull, which is from the Upper Eocene beds, is taken as the type-specimen. A very perfect mandible from the same horizon and locality probably belongs to the same species.

The general form of the head is much the same as in *C. cataphractus*, the length of the snout being about two and a half times its breadth at the orbits. The upper surface in the pre-orbital region is somewhat flattened, while the sides are nearly vertical. There is scarcely any expansion of the premaxillary region; the facial processes of the premaxillæ extend back to the level of the third maxillary tooth, while the palatine processes reach only to the level of the interval between the first and second teeth. The maxillo-premaxillary suture on the palate is directed backwards. The nasals extend just to the nasal opening, though whether they actually formed part of its posterior border is doubtful. There are five teeth in the premaxillæ; the anterior pair are comparatively small and have behind them the deep pits for the reception of the anterior lower teeth, which penetrated the upper surface of the snout. The third and fourth teeth are enlarged. In the maxilla, the alveolar border of which is sinuous, the fourth and fifth and the ninth and tenth teeth are the largest. There were twenty-one teeth in all on either side of the jaw. The teeth themselves are mostly lost, but one shows that they had sharp anterior and posterior carinæ and were somewhat flattened on the inner side. This species, for which the name *Crocodilus articeps* is proposed, differs from *C. cataphractus* and *C. intermedius* in the greater length of the nasals and the slighter expansion of the premaxillary region. Of the Eocene species described from other localities it most nearly resembles *C. Arduini*, Sacco, but differs from it in the smaller degree of expansion of the premaxillary region, the comparative narrowness of the inter-orbital bar, and the less rounded orbits. From *C. Spenceri*, Buckland, the differences are similar. A nearly complete mandible from the same beds is referred to this species. The symphysis is somewhat elongated, extending back to the level of the sixth tooth, but the splenial take no part in its formation. There are fifteen teeth, of which the fourth and tenth are greatly enlarged; the eleventh also is large. In form these teeth are like those of the skull just described. There are well-marked notches for the reception of the upper teeth behind the second, sixth, and seventh teeth, while behind the eleventh and twelfth there are shallow pits.

Some measurements of the type-specimen are:—

	cm.
Distance from anterior angle of orbit to tip of snout	37·0
Width of snout at narrowest	4·8
Width of snout at premaxillary expansion	5·5
Width of skull opposite the front of the orbits	14·0

CROCODILUS MEGARHINUS, n.sp.

The Upper Eocene beds also contain remains of a broad-snouted crocodile which seems to have attained a very large size. The anterior part of a skull shows that the premaxillary region was greatly expanded, though longer in proportion to its width than in *C. porosus*. The facial processes of the premaxillæ extend back to the level of the fourth maxillary tooth. There are five premaxillary teeth, of which the third and fourth are very large. Behind the fifth is a very deep and narrow notch for an enlarged mandibular tooth. To this species the name *C. megarhinus* may be applied. Other remains are known, including the symphysial part of a mandible; these will be described elsewhere. The dimensions of the type-specimen are:—

	cm.
Width of premaxillary expansion	15·6
Width at notch	12·2
Distance from posterior border of nasal opening to tip of snout ...	11
Distance from posterior end of premaxillæ to tip of snout	24·5

CROCODILUS sp.

From the Middle Eocene beds also remains of a broad-snouted crocodile have been collected, but they are so fragmentary that further material is necessary before any attempt to distinguish the species is made.

Of the genus *Tomistoma* one species, *T. africanum*, from the Middle Eocene (Qasr-el-Sagha Beds) of the Fayûm (GEOL. MAG. [4], Vol. VIII (1901), p. 443), has already been described. Now two others, one of slightly later, the other of rather earlier date, are to be considered.

TOMISTOMA GAVIALOIDES, n.sp.

In the Upper Eocene beds of the district remains of a gavial-like crocodile are fairly common. One nearly complete skull has been collected by Mr. Beadnell, and it is to this that the following description refers. This species is interesting because in some respects it is intermediate between *Tomistoma* and *Gavialis*, though much nearer the former, its relationship with which is especially marked in the comparative fewness of the teeth (though they are more numerous than in *T. Schlegeli*) and the extension forwards of the nasals to the premaxillæ, between the facial processes of which they run for some distance.

The form of the occipital surface both above and below the foramen magnum is almost exactly as in *Gavialis*, and, as in that genus, the skull roof is wider than in *Tomistoma Schlegeli*, owing mainly to the large size of the supra-temporal fossæ. The orbits differ from those of the recent *Tomistoma* in being more rounded, as in *Gavialis*, but at the same time they have not the prominent borders found in that genus; in the breadth of the inter-orbital bar also the skull is exactly intermediate. The snout narrows less suddenly than in *Gavialis*, but not quite so gradually as in *Tomistoma Schlegeli*; as in this latter the nasals extend forward to the premaxillæ, in *Gavialis* they are short and separated from the premaxillæ by a long interval. The expansion of the premaxillary region is slight, less than in the true Gavials.

There are 22–23 teeth on either side; in *T. Schlegeli* the number is 20–21, in *Gavialis* 27–29. The premaxillæ bear five teeth, as in the Gavial; in the recent *Tomistoma* there are only four, though in some fossil species referred to this genus there are five. The maxillary teeth seem to have been almost equal in size throughout the series, and to have been directed somewhat outwards and forwards, both Gavial-like characters.

This skull resembles in many respects that described by Toula and Kail[1] under the name *Gavialosuchus eggenburgensis*. This species also is in many ways intermediate between *Tomistoma* and *Gavialis*, but has been referred by Lydekker to the former genus. It differs from the present species in the narrower skull roof, the smaller temporal fossæ, and the raised borders to the orbits; but at the same time, if it were to be regarded as generically distinct from *Tomistoma*, both it and the present species might perhaps be placed in the same genus, *Gavialosuchus*.

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[1] "Ueber einen Krokodil-schädel aus den Tertiärablagerungen von Eggenburg": Denksch. Akad. Wiss. Wien, Bd. L (1885), p. 299, pls. i–iii.

The dimensions of the type-specimen are:—

	cm.
Length of occipital condyle to tip of snout	64·0
Width between outer angles of quadrates	27·0
Greatest width of skull roof	18·0
Width of middle of rostrum	6·4

TOMISTOMA KERUNENSE, n.sp.

An imperfectly known species from the Birket-el-Qurun Beds (Middle Eocene), which are separated from the Upper Eocene deposits containing *T. gavialoides* by the thick Qasr-es-Sagha series, in which *Tomistoma africanum* occurs.

The best specimen is a part of a skull, in which most of the region behind the middle of the orbits as well as the premaxillary portion of the rostrum are wanting. It differs from *T. gavialoides* in having a rostrum which narrows more gradually and the upper surface of which is more regularly convex from side to side; the orbits also are less rounded and the inter-orbital bar broader than in that species. The teeth were larger and are separated by longer intervals. To this species the name *Tomistoma kerunense* may be given.

The reptilian remains from these Egyptian beds are of far less interest than the mammals, since they differ little from their modern representatives. In *Tomistoma gavialoides*, however, we may have an intermediate form, showing how the highly specialized fish-eating Gavial may have arisen from a *Tomistoma*-like reptile, a supposition that is strengthened by the fact that no remains of a true Gavial are known from earlier beds. Dr. E. Fraas has lately announced[1] that he has remains of a species of *Tomistoma* from the lower beds of the Middle Eocene of the Mokattam Hills at Cairo. When these specimens are described perhaps some further light may be thrown on the interrelations of the various long-snouted Crocodilia.

II.—SOME CHANGES OF LEVEL IN THE GLACIAL PERIOD.

By T. F. JAMIESON, F.G.S.

IN Scandinavia there have been various changes of level during the Glacial period, and some geologists of that country are of opinion that the load of ice which lay upon it affords a probable means of accounting for a depression and submergence of the land such as would lead to the formation of those elevated beds of Arctic shells which are met with in the interior of that region. But there has been a later movement of quite a different nature, whereby the Baltic seems to have been converted for a time into a fresh-water lake, and it is to this that I now want to draw attention, as I think the same cause which has been supposed to produce the depression affords a happy means of explaining this curious and later phenomenon also.

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[1] "Neue Zeuglodonten aus dem unteren Mitteleocan vom Mokattam bei Cairo": Geol. u. Palaeont. Abhand., neue Folge, Bd. vi, Heft 3; Jena, 1904.

The depression of a large tract of land by a weight laid upon it would almost of necessity be accompanied by a corresponding rise in the region lying immediately beyond. We see this on a small scale when we push down a hollow in an elastic substance, or when a depression of the soil is caused by the advance of a heavy mound such as a railway embankment, which leads to a bulging up of the ground immediately in front. The depression of the ice-covered area of Scandinavia would therefore probably produce a similar bulging up of the outer region, and thus close the Cattegat and block out the sea from the entrance to the Baltic, thereby converting it for a time into the state of a fresh-water lake. This would happen probably after the Baltic glacier had shrunk considerably, and it is just then that the fresh-water condition seems to have occurred. At an earlier period, when the Scandinavian ice spread far and wide, the bulging up would take place at a much greater distance, and would embrace a larger area. Here again we have evidence of a like result, for we know that the southern part of the German Ocean and the Straits of Dover were converted into dry land during an earlier part of the Glacial period; and that the mammalian fauna of the continent ranged freely over that ground into England. The lower reaches of the Thames too, and other rivers of East Anglia, were also by the same action probably converted more or less into lakes and pools, which appear to have been haunted by the hippopotamus, whose remains are frequently met with in the valley gravel and alluvial deposits of that quarter. In the South of England and in Germany there are other proofs of straining and earth-movement, due possibly to the same heavy pressure exerted by the Scandinavian ice, and propagated outwards beneath the surface. Movements of depression occasioned by forces of this nature must generally be attended in neighbouring regions by strains, fractures, and movements of elevation, which are to be looked upon as the natural accompaniment and complement of the depression caused by the load of ice. Here, then, it seems to me we may find an efficient cause for the production of many such movements, in regard to which no explanation has hitherto been offered.

One of the most obvious changes in the weight of the surface arises from the action of rain, rivers, and glaciers continually wearing and washing down matter into the sea. This incessant degradation must always be wearing away and lightening the mountain regions, so that the tendency in them should be to a slow and gradual rise, whereas on the sea bottom the opposite effect would take place, and there the tendency would be to sink. Such action would tend to the permanence of continents, which otherwise would be worn down much faster. Land is land, I presume, because it is lighter than the area occupied by the sea, and the great mountain regions are probably the least heavy parts of the earth's crust.

Our ignorance of the state of matters in the interior of the earth is so great that we are not justified in dogmatizing on the subject, but the facts observed by geologists seem to show that movements of some kind, even in a lateral direction, are possible at no great depth beneath the surface, although the great internal mass of the earth may be as rigid as certain mathematicians would have us believe. Some degree of plasticity or viscosity in a stratum not far down would suffice to allow of all the movements I have assumed to be possible in the foregoing observations. But whether the outer crust reposes on a stratum of this nature or not, it must, I should think, be in a state of equilibrium, or if not it will move. If the downward pressure is not exactly equalized by the upward resistance, movement must ensue to restore the balance. Hence the level of the surface must always be tending to an exact equilibrium, and must respond to any change, however slight, in the load laid upon it. The response no doubt may be quite infinitesimal, but is it not inevitable? We might compare the action to that of a spring of enormous strength, so strong as to be practically rigid to human observation.

If the views of Adhemar and Croll regarding the Glacial period are right, we may believe that in each hemisphere alternations of great cold with warmer intervals took place owing to the precession of the equinoxes. And if a great load of ice on the land really causes a depression, we may infer that each period of glaciation would be accompanied by a depression or submergence proportionate in some measure to the greatness of the load of ice. Now there seems to be evidence that some such train of events actually did occur both in Scandinavia and Scotland, the severity of glaciation finally becoming less, and the amount of submergence also.

THE ARCTIC SHELL-BEDS OF SCOTLAND.

I have for a long time been of opinion that in the Clyde district and West of Scotland we have at least two distinct sets of marine beds containing northern shells, viz., (1) an older set which attains to much higher elevations (in one case up to fully 500 feet) and has been more or less destroyed by a subsequent development of glaciers and land-ice; (2) a newer set confined to lower levels and which has never been subjected to the same destructive action. In the latter series the species are much more numerous, the shells much more plentiful and in much better preservation, many being evidently in the spot where the animals lived and died — rows of *Mya truncata*, for example, in the position of life, with pieces of the siphuncular tubes still remaining. It is from this series that Mr. Smith, of Jordanhill, got most of his specimens. These two series of shell-beds, I believe, were separated by a long period of land-ice which heavily covered all the west side of Scotland and spread more lightly over the eastern side. I think, therefore, they ought not to be confounded together as has been generally the case, seeing that a great lapse of time and an important change of conditions intervened between them. In the older set the shells are generally more or less crushed and are often covered by masses of boulder-clay, showing that severe glacial conditions had come on after the existence of the mollusca contained in these beds. Such older shelly strata have been found in the southern part of the Isle of Arran, in Cantyre, in Lanarkshire, and other places. In Ayrshire Mr. John Smith has traced them all over the county and at all heights up to 1061 feet. Now on the east side of Scotland we have several examples of these older shell-beds, but it seems to me we have absolutely none corresponding to the later so-called Clyde beds. So far, however, as I am aware this absence of representatives of the Clyde beds on the east side of Scotland has not hitherto been distinctly asserted by anyone, and no doubt this opinion of mine may be disputed. Nevertheless, I think a due consideration should convince anyone who is well acquainted with the shell-beds of the two sides of the country that examples of the later series or so-called Clyde beds really do not exist on the east coast. Nothing like them has turned up on the shores of the Firth of Forth, where, if anywhere, we might expect them to be found. Neither are hey to be seen along the Firth of Tay or the Moray Firth. It is rue that instances of Arctic shell-beds have been met with at Elie n Fife, and at Errol on the Firth of Tay, but they evidently belong o an earlier submergence, and the Rev. Thos. Brown, who carefully examined these deposits and described them in the Transactions of he Royal Society of Edinburgh for 1867, clearly distinguishes them rom the Clyde beds and assigns them, correctly as I think, to an earlier period. The group of mollusca contained in them comprises fewer species, is of a more intensely Arctic or even circumpolar character, and also indicates a greater depth of water. Moreover, the trata at Elie, Tyrie, and Portobello show evidence of disturbance, having been thrown into convolutions by the action of some powerful orce such as the pressure of land-ice, a feature not observable in the ater Clyde beds. These were formed apparently when the last great mantle of ice had passed or was just passing away, whereas the lder shell-beds belong to an earlier time previous to this glaciation, ut subsequent to an older and still greater one. Loch Lomond was t one time a salt-water fiord inhabited by Arctic mollusca belonging o the earlier stage. The shell-beds of that time were then emolished by the later ice coming down the basin, and their emains turned out into the ground beyond. The broken shells may e detected in the railway cuttings between Drymen and Gartness, where I observed them in 1864, both in beds of gravel and in coarse tony mud. Mr. Jack, who afterwards mapped the locality for the Geological Survey, traced a shelly boulder-clay over much of the ground at the south-east corner of the lake, and he attributes the occurrence of the broken shells in the clay to the action of a glacier oming down the bed of the lake and scouring out the marine beds eneath it, an opinion in which I quite agree with him. A great tream of ice had come down Loch Lomond and another down the ne of the Forth. These were separated by the mountain ridge unning from Ben Lomond towards Balfron, and in the lee of this dge there are partially stratified masses of clay, sand, and gravel, which seem to have been left there owing to their sheltered position having saved them from being swept away by the ice. Mr. Jack thinks that these beds were deposited during what he terms 'the great submergence,' but he makes out this submergence to have taken place at a period after the shelly till on the Endrick was formed. This is a point, however, in which I am unable to agree with him. Some of the sand, gravel, and stony mud was probably heaped up by the flank of the glacier which produced the shelly till, and about the same time, but the finer stratified beds of clay and sand near Balfron, I think, are just those portions of the glacial marine beds which escaped destruction owing to their sheltered position behind the ridge separating the two ice streams. The Forth glacier must have gone far eastward, but during its final retreat it has left at the Loch of Menteith a fine group of moraines which show no sign of having ever been submerged by any subsequent change of level, although their base is only about 50 feet above reach of the tide. I am, therefore, decidedly of opinion that no great submergence has taken place since the advance of the glaciers which produced the shelly boulder-clay on the Endrick at the south-east corner of Loch Lomond. But after these glaciers vanished, Loch Lomond (which is only 23 feet above the present sea-level) appears to have again become a salt-water creek inhabited by the later group of northern mollusca, whose shells, not crushed and broken, but entire and undemolished by any subsequent glacier, are still to be found in the present bed of the lake at the island of Inchlonaig and other places, where they had no shelter and where they could not have escaped destruction by such an agency.[1]

Here, then, we have evidence of two distinct deposits of marine beds separated by an interval of land-ice, and it is to this second and lesser submergence that I would assign what we may for convenience call the Clyde beds, although they are by no means confined to the Clyde basin, but are met with in a multitude of places along the west coast and its numerous creeks. The lowest height of the watershed between the Forth and Clyde is 160 feet near Kilsyth, and 220 near Balfron on the line of the Stirling and Balloch Railway. The submergence which led to the formation of the later Arctic shell-beds would therefore not extend across the watershed nor reach so far up, 50 or 60 feet being about the upper limit of these beds in the Clyde district, and the group of mollusca whose remains are found in them does not indicate much depth of water.

When I first made my acquaintance with the Clyde beds more than 40 years ago, I was struck with the abundance of the shells, their fine preservation, and the multitude of places in which they occur, all so unlike what I had experienced on the east side of the Kingdom. But I felt at a loss to understand how there should be such a difference between the two sides of the country, and it was not until long after that I came to perceive what I now take to be the true meaning of it all.

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[1] See J. Adamson, in Wernerian Soc. Memoirs, vol. iv, p. 334; also Palæontographical Soc., vol. xxviii, p. 42.

The first thing that led me to suspect how the matter stood was the discovery of the older beds on the west coast, and the mode in which they generally presented themselves, for I then began to see that these were the true equivalents of our east coast ones, and that the reason of the great difference between them and the later Clyde beds was mainly that the latter had never been exposed to the same treatment. They had escaped the destructive action of the last glaciation and belonged to a newer stage. Hence the better preservation of the beds, the greater abundance of the fossils, and the more perfect state in which the shells are found.

The red clay in which Arctic shells (generally broken) have been got at Belhelvie and other places on the Aberdeenshire coast, can be shown to be of earlier date than the last glaciation, seeing that it is covered by the gravelly moraines of the last stream of ice which came down to the coast along the valleys of the Dee and Don. Agassiz, who visited these gravel hills along with Dr. Fleming in 1840, was confident they were moraines, while Fleming was equally satisfied that their formation was posterior to the shell-bearing clay beside them, seeing that they not only lie above the clay, but also occasionally contain rolled masses of it (see "Lithology of Edinburgh," p. 82), all which I can confirm. This reddish clay of the east midland coast of Scotland contains not only Arctic shells occasionally, but also bits of chalk, which are sometimes well scratched and rubbed as if by ice. These chalk fragments were probably brought to our shores by the Scandinavian ice which passed over and destroyed some of the Danish chalk. They are by no means uncommon at Belhelvie and Montrose, and occur also at Barry, Portobello, and Peterhead. There is, therefore, some reason to believe that all these clays of the east midland coast of Scotland which contain Arctic shells and bits of chalk belong to approximately one and the same period — a period previous to the last general glaciation, and consequently earlier than the later Clyde beds, with which they should not be confounded.

Now if I am right as to the absence of the later Arctic shell-beds on the east side of Scotland, how are we to account for it? It seems to me that it might be simply the result of the unequal pressure of ice on the two sides of the kingdom, the heavy load on the west causing a depression and submergence which did not affect the east side. Indeed, the tendency there would rather be to a rise owing to the reason previously mentioned.

In my paper on the Parallel Roads of Glen Roy in 1863, I drew particular attention to the evidence of extreme glaciation along the west coast, and I suggested that as the rainfall there far exceeds that of the east, so in former times the fall of snow would be in like excess, hence heavier ice would result. The rainfall along the west of Scotland is two or three times what it is on the east, while on the mountains the excess is far greater. The annual average measured by the rain-gauge on the top of Ben Nevis for the nineteen years ending 1903 is no less than 160 inches, while at Fort William, close to the bottom of the hill, it is not more than 78 inches, or just about half. On the east coast of Scotland it is scarcely 30 inches. When we consider how the ice grows upon heavily snowed regions, owing to the continual storage from year to year, we may easily imagine what an enormous excess must have resulted on the west side of Scotland. In fact, we know this from the state of matters that existed in Inverness-shire just before the glacier lake of Glen Roy was formed, when the western ice overflowed all the passes on the east side of the Great Glen, although these passes are actually higher than those on the west, which led out to the Atlantic. This difference between the two sides of the country in regard to the amount of ice that lay upon them has never been adequately realized, although it affords the only true means of explaining many remarkable features in the character of the surface, and I think it might be sufficient to account for that depression of the western side which led to the formation of the Clyde beds.

III.—FURTHER NOTE ON *CYCLUS JOHNSONI*, FROM THE COAL-MEASURES NEAR DUDLEY.

By HENRY WOODWARD, LL.D., F.R.S., V.P.Z.S., F.G.S.

MY friend Professor Lapworth kindly sent me, for identification, in July last the split portions of two nodules containing examples of the interesting little Crustacean genus *Cyclus*, from the 'Pennystone' Ironstone of the Coal-measures near Dudley, obtained by Miss Ethel M. R. Wood, M.Sc., of the University of Birmingham, and I have obtained permission to publish a note thereon, supplementary to my paper in 1894.[1] In that paper I described, among other species, one which I named *Cyclus Johnsoni* (op. cit., Pl. XV. Figs. 4–7, pp. 537–538), from the Coal-measures, Coseley, near Dudley, which is identical with Miss Wood's specimens. As one of these latter displays some further details of appendages I have given a figure of it here as tending better to elucidate the structure of this curious genus. (See Woodcut on p. 491.)

This specimen shows the broad, raised, and grooved margin of the shield- or disc-like carapace, the centre of which is removed and displays, as in *Cyclus Rankini* (op. cit., Pl. XV, Fig. 8), the radiating ridges of the ventral or sternal arches once giving attachment to seven or more pairs of simple swimming- or walking-feet, each having been no doubt furnished with an endopodite and exopodite, as in the limbs of Trilobites,[2] subserving the purposes of branchiæ and limbs, the bases being perhaps also maxillæ, or they may have been furnished with such simple appendages as are seen in the larval stages of modern *Limulus*.[3]

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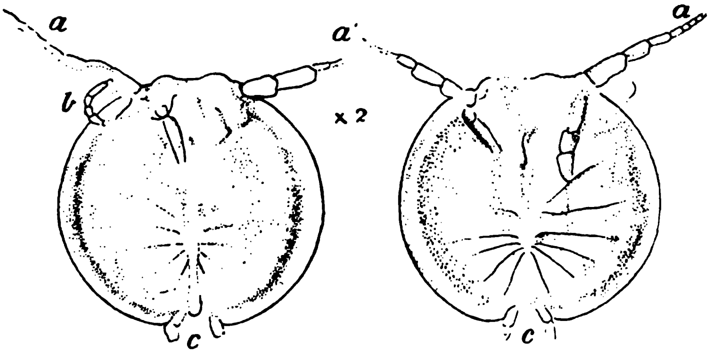
[1] See "Contributions to our Knowledge of the genus *Cyclus*, from the Carboniferous Formation of various British localities": GEOL. MAG., 1894, pp. 530–539. Plate XV.

[2] C. D. Walcott: GEOL. MAG., 1894, p. 246, Pl. VIII, Fig. 6. C. E. Beecher: GEOL. MAG., 1896, p. 193, Pl. IX.

[3] See Mon. Brit. Foss. Crustacea, Order Merostomata, by H. Woodward, pt. v, *pp.* 214–218, pl. xxxiii and explanation: Pal. Soc. Mon., 1878.

Bearing in mind that *Prestwichia rotundata*, *P. Birtwelli*, and other Coal-measure forms of Xiphosura, apparently, are not more advanced in development, as compared with the living king-crab, than the later larval stages of *Limulus polyphemus* when first quitting the egg, as represented in our monograph above quoted, then, if we venture to assume that the curious forms referred to the genus *Cyclus* are but the larval stages of those Coal-measure *Limuli*, we may most certainly conclude that they would represent in point of structure the still earlier phases of *Limulus*, they having been, so to say, more precocious in quitting the egg than their modern representatives. For example, in the earlier stages of development of the fertilised egg in *Limulus polyphemus* (pl. xxxiii, figs. 1 and 2, op. cit.) only



Cyclus Johnsoni, H. Woodw., 1894.

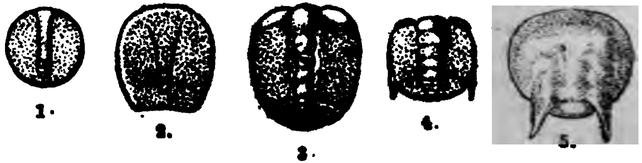
Impression and counterpart of a specimen from the 'Pennystone' Ironstone band of the Coal-measures, Coseley, near Dudley. Drawn twice nat. size. *a*, *a*, antennæ; *b*, endopodite (?) of one of mouth-organs; *c*, *c*, appendages of the posterior segment of the body. (Original specimen in Birmingham University Museum.)

seven or eight pairs of simple limbs are seen, corresponding with a similar number of cephalic somites, partially united dorsally, the thoracico-abdominal segments and the short telson not being developed until a much later stage.

This early or premature hatching out of the young characterises the Phyllopoda, and indeed most living Entomostraca. In those Trilobites whose early history is known the young, as in *Sao*, *Ptychoparia*, *Triarthrus*, *Proetus*, *Acidaspis*, and *Dalmanites*, are almost as simple, or even more so, in their earliest known stages as *Cyclus* (see Beecher and Barrande's figures *infra*, p. 492).

It must, of course, be borne in mind that this is only a suggestion, and may hereafter prove to be of no value; still, the fact remains that the first considerable development of *Limulus*-like Crustaceans occurs in the Coal-measures, only one small form, *Neolimulus*, being met with earlier in the Upper Silurian of Lesmahagow. We may also justly assume that *Limuli* may be found in all those deposits younger than the Coal-measures, seeing that king-crabs are living at the present day widely distributed on the east coast of North

America, and in the seas of China, Japan, and Molucca; and they have already been met with fossil in the Jurassic, Cretaceous, and Tertiary strata.



FIGS. 1–5.—Youngest larval or 'Protaspis' stage of some Trilobites (after Beecher[1]), for comparison with *Cyclus*.

FIG. 1.—*Sao hirsuta*, Barrande. Cambrian: Skrey, Bohemia.
,, 2.—*Ptychoparia Kingii*, Meek. Cambrian: North America.
,, 3.—*Proetus parviusculus*, Hall. Ordovician: New York, U.S.
,, 4.—*Dalmanites socialis*, Barr. Ordovician: Bohemia.
,, 5.—*Olenellus asaphoides*, Emmons, sp. Lower Cambrian (*Olenellus* zone).

IV.—SEDGWICK MUSEUM NOTES.

NEW FOSSILS FROM THE HAVERFORDWEST DISTRICT. V.

By F. R. COWPER REED, M.A., F.G.S.

(PLATE XXIV.)

LAMELLIBRANCHIATA.

A FEW species of Lamellibranchs were recorded by Messrs. Marr and Roberts[2] from the *Trinucleus seticornis* Beds of Haverfordwest; and though some new species may now be added to their number with the aid of the numerous specimens collected by Mr. V. M. Turnbull, yet a complete list of the species is at present impossible owing partly to the imperfect condition of many of the fossils and partly to the unsatisfactory state of our knowledge of this class as developed in British Ordovician rocks.

The Slade and Redhill Beds have yielded the majority of the species, and the following may be enumerated:—

REDHILL BEDS.

Ctenodonta obliqua, Portl. (?).
,, *transversa*, Portl. (?).
,, *varicosa*, Salt. (?).
,, *sladensis*, sp. nov. (var.).
,, *subscitula*, sp. nov.
,, two sp. indet.
Arca (*Palæarca*), sp. indet.
Cyrtodonta (?) *cancellata*, sp. nov.

SLADE BEDS.

Orthodesma semiradiata, sp. nov.
Ctenodonta lingualis, Phill. (?).
,, *sladensis*, sp. nov.
,, *transversa*, Portl. (?).
,, two sp. indet.

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[1] Figs. 1–4, from Zittel's Textbook of Palæontology, translated and edited by C. R. Eastman (London, 1900; 8vo), p. 618. Fig. 5 from C. D. Walcott's Lower Cambrian Fauna, pl. lxxxviii, fig. 1.

[2] Marr & Roberts: Quart. Journ. Geol. Soc., vol. xli (1885), pp. 476–490.

Arca (Palaearca) Turnbulli, sp. nov.
Whitella (?) *inutilis*, sp. nov.
Ambonychia cf. *radiata*, Hall.
Modiolopsis Martini, sp. nov.
 ,, *subgradata*, sp. nov.
 ,, sp. indet.
Goniophora cf. *cymbæformis*, Sow.

ORTHODESMA SEMIRADIATA, sp. nov. (Pl. XXIV, Figs. 8, 9, 10, 10*a*.)

DESCRIPTION.—Shell elongate-oval, narrow, about three times as ng as high, gaping slightly at both ends; inferior and superior argins subparallel; beaks small, not prominent, scarcely rising bove hinge-line, directed forwards, situated at about one-fourth or ne-fifth the length of the shell from the anterior end, with small distinctly defined lunulate area in front of them; anterior end of hell short, narrowed, acutely rounded; posterior end obliquely runcated with inferior angle subacutely rounded; cardinal margin traight, about one-half to two-thirds the length of the shell; nferior margin gently arcuate, curving up sharply in front. Valves ompressed, very slightly convex, with weak, rounded, umbonal idge running obliquely backward from beak towards posteronferior angle, before reaching which it becomes obsolete; surface f valve flattened above umbonal ridge; no distinct medial depression resent. Surface of valves ornamented with sharp, concentric, subqual lines and striæ, well marked in front of umbonal ridge, behind hich they are nearly obsolete; umbonal ridge and post-umbonal urface marked with fine, low, closely placed, rounded radii, most istinct near inferior angle. Anterior adductor impression subarginal, ovate, more or less distinct; posterior adductor and pallial npression not visible. Shell apparently thin.

DIMENSIONS.

	I.	II.	III.	IV.	V.
Length	26·5	32·5	23·5	19·0	29·0 mm.
Height (at beak)	6·5	12·5	8·5	4·5	7·5 mm.
Distance of beak from anterior end	6·0	—	—	—	—

HORIZON AND LOCALITY.—Slade Beds: roadside near St. Martin's emetery, Haverfordwest.

REMARKS.—This species is fairly common in the Slade Beds, near t. Martin's Cemetery, Haverfordwest, a locality at which many amellibranchs are found. The specimens are frequently somewhat istorted and crushed, and suggest a thin delicate shell. The true eneric position of this shell is somewhat doubtful, since we are gnorant of its hinge-characters, and since the classification and nomenclature of the Lower Palæozoic Lamellibranchs is in a notoriously nsatisfactory and unsettled condition. Ulrich[1] has recently revised he members of this group occurring in the Ordovician beds of innesota, but his diagnoses are not always easy to apply to the poorly preserved material from the British formations, and consequently the new or revised generic terminology adopted by him cannot in many cases be employed without some element of uncertainty.

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[1] Ulrich, Lower Silur. Lamell. Minnesota: Geol. Surv. Minnes., vol. iii, pt. 1, 895, pp. 475–628.

In the present case there are three genera which have some external points of resemblance to this Slade form. *Orthodesma* resembles our shell in general shape, the gaping of both ends, and the position of the beaks and muscles, but it is stated to have a broad mesial sulcus which is certainly absent in the Slade species. On the other hand, *O. canaliculatum*, Ulrich,[1] has only a very shallow sulcus, and possesses obscure posterior radii, a kind of ornamentation apparently wanting in other members. *O. minnesotense*, Ulrich,[2] also appears to be allied to our form, judging from the figures and description; the shape of the shell is nearly identical, and the mesial sulcus appears to be absent. *Endodesma*[3] has a more or less defined lunule in front of the beaks, but the mesial depression is strong and the basal margin consequently sinuate; however, the general external aspect of some species is not very dissimilar from *Orthodesma*. *Whiteavesia* (= *Actinomya*)[4] has tightly closing valves and no lunule, but a radial ornamentation on the surface of the shell is sometimes well marked.

On the whole, of the above three genera our species seems most probably to belong to *Orthodesma*. The external ornamentation recalls *Nuculites poststriatus*, Emmons,[5] of the Trenton and Hudson River groups, but the shell is much shorter and higher, the beaks are subanterior, and the umbonal ridge stronger and more prominent. *Modiolopsis postlineata*, McCoy,[6] with a similar ornamentation, is a shorter shell, with almost terminal beaks and a more abruptly truncated posterior end, but the type is imperfect, and it may be allied to this new Slade species.

CTENODONTA SLADENSIS, sp. nov. (Pl. XXIV, Fig. 12.)

DESCRIPTION.—Shell subquadrate-ovate or subrhomboidal, about one and a half times as long as high, thin, compressed; anterior end rounded; posterior end obliquely truncate above, rounded below, meeting hinge-line at about 45°; inferior margin broadly rounded; cardinal margin behind beaks straight and about half the length of shell; beaks small, not prominent, directed forwards, situated at about one-third the length of the shell from anterior end, which is slightly excavated below them. Umbonal ridge sharply marked, slightly arched; cardinal slope above it flattened, compressed. Teeth behind beak obliquely inclined, transverse, 10 or more in number. Surface of shell regularly marked with very fine concentric striæ.

[1] Ulrich: op. cit., p. 520, pl. xxxvii, figs. 7–11.

[2] Ulrich: op. cit., p. 517, pl. xxxvii, figs. 12–14.

[3] Ulrich: op. cit., p. 525.

[4] Ulrich: op. cit., pp. 513, 628.

[5] Emmons: Geol. Rep., 1842, p. 399, fig. 3. Hall: Palæont. New York, vol. i, pp. 151, 301, pl. xxxiv, figs. 2*a*, *b*; pl. lxxxii, figs. 10*a*, *b*.

[6] McCoy: Synops. Palæoz. Foss. Woodw. Mus., p. 268, pl. ii, fig. 22.

Dimensions.

	I (from Slade Beds).	II (var. from Redhill Beds).
Length	13·5	14·0 mm.
Height	10·0	9·5 mm.

Locality and Horizon.—Slade Beds: roadside 110 yards west of St. Martin's Cemetery; (variety) Redhill Stage, Prendergast Mill Lane.

Remarks. — This shell has a very compressed form, and its subquadrate shape and subauriculate appearance give it a considerable similarity to *Nucula deltoidea*, Phillips.[1] But the latter is less obliquely truncated behind, the umbonal ridge is less sharply marked, and the teeth appear to be more numerous. Ulrich's *Ct. Calvini*[2] is apparently more allied. The Redhill specimens are rather more ovate than those from the Slade Beds, and have the teeth generally better preserved.

Ctenodonta subscitula, sp. nov. (Pl. XXIV, Figs. 13, 13*a*.)

Description.—Shell elongate-ovate, about twice as long as high, highest at beaks, narrowed posteriorly, strongly convex, most so about middle, somewhat compressed behind. Anterior end broadly rounded, excavated above in front of beaks; posterior end produced, subacutely pointed, very obliquely truncated above; inferior margin moderately convex. Hinge-line gently arcuate, with series of about 22 small transverse, slightly oblique teeth in front of beaks, increasing somewhat in size towards the front and extending from beaks to anterior end of shell; post-umbonal series of teeth meeting anterior series at very obtuse angle, but continuous with it and consisting of 9–11 larger transverse teeth increasing rapidly in size posteriorly and successively becoming more obliquely inclined. Beaks prominent, incurved, rising above hinge-line, scarcely bent backwards, situated at about one-third the length of the shell from anterior end. Surface of valves convex, with strong, subangular, curved, diagonal ridge running back from beak to upper posterior angle, limiting a more or less excavated cardinal slope inclined at nearly a right angle to the general convex surface of the valve. Surface of shell marked with regular, equidistant, rather strong, concentric striæ.

Dimensions.

	I.	II.
Length	16·5 ...	13·5 mm.
Height	9·0 ...	7·0 mm.

Horizon and Locality. — Redhill Beds: Prendergast Place and Lane.

Remarks.—The characters of the dental series combined with the shape and general features of the shell distinguish it from the other numerous species of *Ctenodonta* found in the Redhill and Slade Beds, and I am not acquainted with any described species which can be considered identical with it. McCoy's so-called *Arca scitula*[1] bears a considerable external resemblance to our Redhill form, but no information as to the internal characters of this Irish shell has been published.

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[1] Phillips: Mem. Geol. Surv., vol. ii, pt. 1, p. 366, pl. xxii, fig. 5.

[2] Ulrich: op. cit., p. 596, pl. xlii, figs. 61–64.

ARCA (PALÆARCA) TURNBULLI, sp. nov. (Pl. XXIV, Fig. 14)

DESCRIPTION.—Shell oblong, more than twice as long as high; convex, most so about middle; hinge-line straight, about three-fourths the length of shell; beaks broad, obtuse, directed forward, rising above hinge-line, incurved, situated at about one-fourth the length of hinge-line from front end, and at about one-third to two-fifths the length of shell; anterior end of shell obliquely truncate above, acutely rounded at inferior angle; inferior margin slightly arcuate; posterior end obtuse, abruptly truncate, not produced, meeting hinge-line at about 60°–70°. Teeth transverse, inclined away from beak, about 8–10 visible behind beak. Surface of valves moderately convex with umbonal ridge running obliquely back to posterior end at angle of about 20° to hinge-line; cardinal slope behind and above umbonal ridge compressed, flattened; anterior end in front of beaks somewhat depressed above, but convex below. Surface of shell marked with fine concentric striæ and weak growth-wrinkles.

DIMENSIONS.

Length	... ...	20·5 mm.
Height	... ...	9·5 mm.

LOCALITY AND HORIZON.—Slade Beds: roadside 150 yards west of St. Martin's Cemetery, Haverfordwest.

REMARKS.—This species resembles *A. edmondiformis*,[2] but the shell is relatively longer, the beaks are more central, and the truncation of the ends is different. Portlock's *Arca cylindrica*[3] is more elongated and the beaks more anterior; and in his *A. subtruncata*[4] the shell is shorter and broader, and the beaks are more centrally situated.

CYRTODONTA (?) CANCELLATA, sp. nov. (Pl. XXIV, Figs. 11, 11*a*.)

DESCRIPTION.—Shell quadrato-ovate, slightly oblique, truncated abruptly in front, broadly rounded behind, about 1¼ times as long as high, widening a little posteriorly; surface moderately convex, most so about middle of valves. Beaks anterior, low, small, scarcely rising above hinge-line, directed forwards. Anterior margin nearly straight, abrupt, meeting inferior and superior margins at nearly right angles. Inferior margin slightly arcuate. Posterior end obtuse, broadly rounded below, obliquely truncate above. Superior cardinal margin straight, about three-fourths the length of shell. Hinge-line bent at nearly a right angle at beaks. Broad, rounded, ill-defined umbonal ridge running obliquely from beak to posterior angle, increasing in height to middle, then decreasing behind and merging into general convexity of valve. Surface of shell ornamented with numerous fine, regular, equidistant, straight, radiating, raised lines running from beak to inferior margin on anterior two-thirds of shell, but faint or absent on posterior portion; crossed by rather irregular, somewhat undulating, not always equidistant, fine concentric fimbriations which become much more numerous and regular on posterior third of shell where the radii are absent.

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[1] McCoy: Synops. Silur. Foss. Irel., p. 20, pl. ii, fig. 6.

[2] McCoy: Synops. Brit. Pal. Foss. Woodw. Mus., p. 283, pl. i k, figs. 2, 3.

[3] Portlock: Geol. Rep. Londond., p. 428, pl. xxxiv, fig. 9.

[4] Ibid., p. 427, pl. xxxiv, fig. 1.

DIMENSIONS.

Length	9·0 mm.
Height	7·0 mm.
Thickness (one valve)	3·5 mm.

HORIZON AND LOCALITY. — Redhill Beds: 80 yards north of Prendergast Place, Haverfordwest.

REMARKS.—The true generic position of this pretty little shell is somewhat doubtful, for though we have the internal cast of the shell and external imprints of the surface, the cardinal portion is not well preserved, and the region near the beaks is somewhat abraded. No trace of teeth is visible, but the ligament seems to be external behind the beaks. I am inclined to associate it with *Cyrtodonta*, some species of which bear much resemblance in external shape, though the ornamentation in our specimens is peculiar.

WHITELLA (?) INUTILIS, sp. nov. (Pl. XXIV, Figs. 7, 7*a*.)

DESCRIPTION.—Shell small, oblique, very elongate-ovate, somewhat wedge-shaped, narrowing posteriorly; strongly ventricose and inflated. Hinge-line short, straight behind beaks, and less than one-third the oblique length of the shell, meeting posterior margin at angle of about 135°, with elongate narrow escutcheon grooved on each side for reception of ligament. Posterior end of shell much produced, very obliquely truncated, margin nearly straight, with inferior angle acutely rounded; inferior margin slightly arcuate, inclined to posterior margin at about 30°–40°; anterior end of shell very short, rounded. Beaks rather prominent, small, acute, directed forward, rising above hinge-line, incurved, situated at about one-third the length of hinge-line. Strongly elevated, subangular umbonal ridge, slightly arched upwards, running from beak to posterior basal angle, nearer upper than lower margin of shell, giving valves an inflated appearance; convexity of ridge increasing from beak to middle of valve and then decreasing gradually to extremity. Surface of shell marked with rather strong concentric striæ and wrinkles, and by a few faint, gently curved, radiating striæ, especially distinct on the region anterior to the umbonal ridge.

DIMENSIONS.

Length	15·0 mm.
Height	8·0 mm.
Thickness	6·5 mm.

HORIZON AND LOCALITY.—Slade Beds: roadside near St. Martin's Cemetery, Haverfordwest.

Remarks.—The true generic position of this little shell (of which I have seen only one well-preserved specimen) is somewhat difficult to decide. At first I was inclined to put it in *Goniophora*, though that genus is typically Silurian. But on comparison with the description and figures of the American genus *Whitella*[1] from the Ordovician of Ohio, Minnesota, etc., the shape, the presence of the strong umbonal ridge and escutcheon lead me to associate it preferably with the latter genus. *Wh. sterlingensis*, Meek & Worthen,[2] and *Wh. præcipta*, Ulr.,[3] are species which may be compared with it.

AMBONYCHIA (BYSSONYCHIA) cf. RADIATA, Hall.

There is one fragmentary cast of a large Lamellibranch from the Slade Beds in Mr. Turnbull's collection which may be compared with Hall's *Ambonychia radiata*[4] from the Hudson River group. The umbonal portions of both valves in juxtaposition are preserved as internal casts, and there is also the imprint of the exterior of one valve. The ventricose shape of the valves, the pointed incurved beaks, and the regular, low, radiating plications, 30–40 in number, ornamenting the surface, can be distinctly seen, but no other structural features are distinguishable. The fragment which represents the anterior portion of the shell measures about 27 mm. in length, but the shell when complete must have been about twice this length. The occurrence of this specimen is worth noting, as no example of a Lamellibranch resembling *A. radiata* has been previously recorded from the Slade Beds; but it is to be hoped that better material for description will be subsequently obtained. The species has been found in the Corona Beds of Cross Fell. It may be mentioned that Ulrich[5] has put *A. radiata* into a new genus *Byssonychia*, separating it from the typical *Ambonychia bellistriata*, Hall.

MODIOLOPSIS MARTINI, sp. nov. (Pl. XXIV, Figs. 1–4.)

DESCRIPTION. — Shell small, obliquely elongate, expanding posteriorly, convex. Cardinal margin straight; anterior end small, narrowed, rounded; beaks small, obtuse, incurved, moderately prominent, situated at about one-fifth or one-sixth the length of the shell from anterior end; inferior margin gently sinuated at about one-third or one-fourth of its length, curving round gently at posterior extremity; posterior end of shell broad, nearly twice as wide as anterior end, strongly rounded. Valves convex, more or less ventricose, with indefinite rounded, broad, umbonal ridge running obliquely back from beak; shallow indistinct sulcus running from beak in front of umbonal ridge to inferior margin, which it slightly sinuates; surface of valves behind umbonal ridge more or less flattened. Surface of shell ornamented with fine concentric growth-lines and striæ, some of which are stronger than others.

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[1] Ulrich: op. cit., p. 564.
[2] Ulrich: op. cit., p. 567, pl. xli, figs. 27, 28.
[3] Ulrich: op. cit., p. 574, pl. xli, figs. 15, 16.
[4] Hall: Palæont. New York, vol. i (1847), p. 292, pl. lxxx, figs. 4a–l.
[5] Ulrich: op. cit., p. 498.

MENSIONS.

	I.	II.
Length	15·0	15·0 mm.
Height at beak	4·5	5·0 mm.
Height at posterior end	7·5	7·0 mm.

ORIZON AND LOCALITY.—Slade Beds: roadside near St. Martin's etery, Haverfordwest.

EMARKS.—The above described species varies somewhat in its ortions, but is certainly distinct from the British species iously described from Ordovician rocks which can be referred e genus *Modiolopsis* in the restricted sense in which the term is by Ulrich (op. cit., p. 502). The definition given by him is the wing:—"Shell more or less elongate, usually subovate, widest riorly; valves moderately ventricose, closing tightly all around. s small, near the anterior extremity; umbones depressed by ttening or depression which crosses the valves obliquely, and ning causes a straightening or sinuation of the basal outline. e of moderate strength, rarely straight, generally somewhat ite, without well-marked teeth; an obscure oblique thickening ath the beak of one valve and a corresponding depression in the : occasionally distinguishable. Ligaments linear, external and nal, chiefly the former. Anterior adductor impression sub-, large, deep, sharply defined on the inner side, occupying the er part of the small anterior end. Posterior scar very faintly essed, large, subcircular, situated near the centre of the posterior of the cardinal slope. Pallial line simple. Anterior pedal le forming a minute pit in the under side of the hinge- beneath the beak. Posterior pedal muscles large, attached above and in front of the adductor. Type: *M. modiolaris,* ad, sp."

e Slade species appears to be allied to *M. arguta,* Ulrich cit., p. 506, pl. xxxvi, figs. 3–6), and *M. nana,* Ulrich (op. cit., 07, pl. xxxvi, fig. 7), from the Trenton and Galena Shales. British shells attributed to *M. modiolaris,* Conr., and *M. Nilsoni,* sp., are much shorter and higher, and have a broader anterior Salter's *Mytilus gradatus*[1] is likewise a less elongated form. lock's *Modiola expansa*[2] from Desertcreat is allied, but un- tedly distinct from our species.

ere is a variety of *M. Martini* occurring in association with ypical form, and scarcely separable from it specifically; it is cterised by possessing a less elongated shape, a smaller ning of the posterior end, a somewhat broader anterior mity, and rather stronger varices of growth on the surface. specimens are mostly not well preserved, and intermediate s connecting it with the type are not uncommon. Some mens resemble the longer forms of *M. gradata,* Salter (op. cit., 3 and 4), but the latter occurs in the Ludlow Beds, and is ably distinct.

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[1] Salter: Mem. Geol. Surv., vol. ii, pt. 1, p. 363, pl. xx, figs. 3–5.

[2] Portlock: Geol. Rep. Londond., p. 426, pl. xxiii, fig. 6.

MODIOLOPSIS SUBGRADATA, sp. nov. (Pl. XXIV, Figs. 5, 6.)

DESCRIPTION. — Shell subquadrate to transversely ovate, short, oblique, widening posteriorly, about 1¼ to 1½ times as long as high; greatest height at about two-thirds of its length. Hinge-line straight, extending about two-thirds the length of the shell behind the beaks. Anterior end of shell somewhat narrowed, subtruncate, rounded, about two-thirds the greatest height of the shell. Inferior margin slightly convex, oblique, gently sinuated. Posterior end broadly rounded, regularly convex; inferior angle not produced. Beaks situated at about one-third the length of the shell from anterior extremity, small, obtuse, rising a little above hinge-line. Surface of valves gently convex, with a more or less developed rounded umbonal ridge traversing valve; cardinal slope somewhat flattened; mesial depression faint or nearly obsolete, but always indicated on inferior margin by sinuation of edge. Surface of shell marked with concentric striæ and a few stronger growth-ridges, meeting hinge-line at an angle between 75° and 90°.

DIMENSIONS.

	I.		II.		III.
Length	10·5	...	9·0	...	14·5 mm.
Maximum height ...	8·0	...	7·5	...	10·0 mm.

HORIZON AND LOCALITY.—Slade Beds: roadside near St. Martin's Cemetery, Haverfordwest.

REMARKS.—The short, broad, subquadrate shape of this species, especially emphasised in the younger and smaller specimens, recalls both *M. gradata*, Salt.,[1] and *M. quadrata*, Salt.,[2] but the hinge-line is longer and the inferior angle not produced as in the former, while the latter has a less oblique shape, the inferior margin is not sinuated, and the anterior end less narrowed.

GONIOPHORA cf. CYMBÆFORMIS (Sow.). (Pl. XXIV, Figs. 15, 15*a*.)

There is a large Lamellibranch from the Slade Beds which bears a great resemblance to *Goniophora cymbæformis* (Sow.), but this species typically belongs to a much higher horizon (i.e. Ludlow). Our single Slade specimen, which measures 52 mm. in length, 23 mm. in height, and 29 mm. in depth, has the peculiar elongated form with very deep valves, incurved anterior beaks, strong angular umbonal ridge, pointed extremity, and large flattened cardinal region and posterior side inclined at an angle of 45°–60° to the general convex surface of the shell. The beaks are small, but acute, and have a distinct cordate, slightly depressed lunule below them. Below the umbonal ridge the valve is rounded and convex, and the shell is marked with concentric striæ and rugæ, the latter being strongest and most regular near the beaks and on the anterior part of the umbonal ridge. The much flattened elongate cardinal slope is only marked with fine concentric striæ, the sudden change in the character

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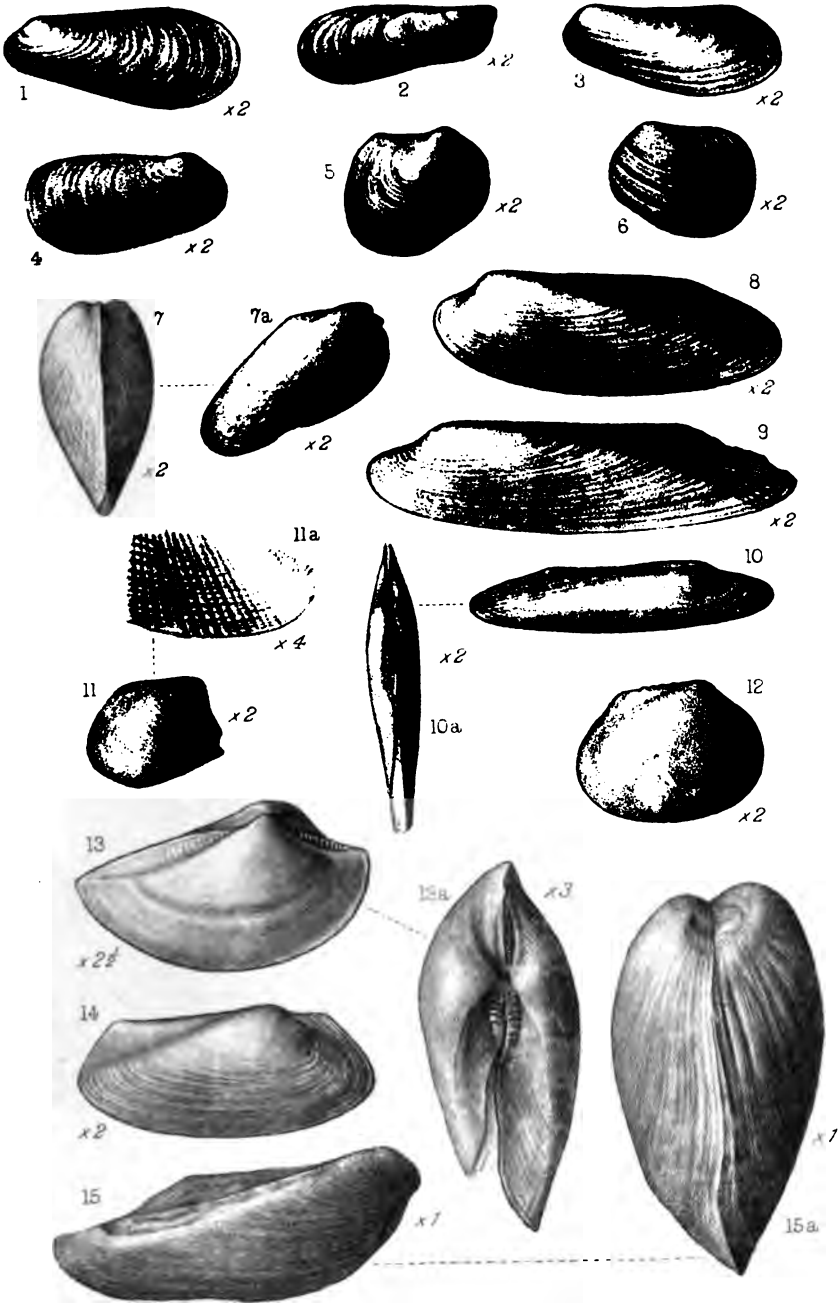
[1] Salter: Mem. Geol. Surv., vol. ii, pt. 1, p. 363, pl. xx, figs. 3–5.

[2] Ibid., p. 363, pl. xx, fig. 1.



G. M. Woodward del et lith.
West, Newman imp.

Lamellibranchs from Haverfordwest.

of the ornamentation being conspicuous. Our specimen is undoubtedly somewhat compressed and distorted, but its close relations or perhaps identity with the Silurian species *G. cymbæformis* cannot be disputed. Sowerby's[1] description of the Upper Ludlow shell is as follows:—"Transversely oblong; valves deep, carinated; the keel acute, extending from the beak to the angular extremity of the narrow, oblique, produced posterior side; beaks short, incurved, close to the small heart-shaped anterior side."

EXPLANATION OF PLATE XXIV.

Fig. 1.—*Modiolopsis Martini*, sp. nov. Slade Beds: near St. Martin's Cemetery, Haverfordwest. × 2.
,, 2.—Ditto. Same horizon and locality. × 2.
,, 3.—Ditto. Same horizon and locality. × 2.
,, 4.—Ditto. Same horizon and locality. × 2.
,, 5.—*Modiolopsis subgradata*, sp. nov. Same horizon and locality. × 2.
,, 6.—Ditto. Same horizon and locality. × 2.
,, 7.—*Whitella* (?) *inutilis*, sp. nov. Internal cast, inferior view. Same horizon and locality. × 2.
,, 7*a*.—Ditto. Same specimen, side view. × 2.
,, 8.—*Orthodesma semiradiata*, sp. nov. Same horizon and locality. × 2.
,, 9.—Ditto. Same horizon and locality. × 2.
,, 10.—Ditto. Same horizon and locality. × 2.
,, 10*a*.—Ditto. Same specimen, cardinal view, showing gaping extremities of shell. × 2.
,, 11.—*Cyrtodonta* (?) *cancellata*, sp. nov. Internal cast. Redhill Beds: Prendergast Place, Haverfordwest. × 2.
,, 11*a*.—Ditto. Same specimen. Portion of exterior of right valve, showing ornamentation. × 4.
,, 12.—*Ctenodonta sladensis*, sp. nov. Internal cast. Slade Beds: near St. Martin's Cemetery, Haverfordwest. × 2.
,, 13.—*Ctenodonta subscitula*, sp. nov. Internal cast. Redhill Beds: Prendergast Place, Haverfordwest. × 2½.
,, 13*a*.—Ditto. Same specimen, showing cardinal characters. × 3.
,, 14.—*Arca* (*Palæarca*) *Turnbulli*, sp. nov. Slade Beds: near St. Martin's Cemetery, Haverfordwest. × 2.
,, 15.—*Goniophora* cf. *cymbæformis* (Sow.). Same horizon and locality. Nat. size.
,, 15*a*.—Ditto. Same specimen, inferior view. Nat. size.

V.—Rodents from the Pleistocene of the Western Mediterranean Region.

By Dr. C. I. Forsyth Major, F.Z.S.

(*Concluded from the October Number, p.* 467.)

Nice.—Among the mammalian remains enumerated by Risso from the bone breccia of the Castle Catinat at Nice, are bones and teeth of '*Lagomys.*'[2] Remains of the same genus have been more recently mentioned by Rivière, from a palæolithic deposit discovered by him in a small cave, Lympia, inside the town of Nice.[3]

Mentone. — On pl. xvii ("Faune des grottes de Menton"), fig. 10, of Rivière's well-known publication,[1] is represented a left mandibular ramus of a "*Lagomys* d'assez petite taille," according to the explanation of the plate. In the dimensions, which are by no means small for a member of the family, as well as in the contours of the ramus, it corresponds with the *Prolagus* from Corsica; it certainly belongs to the latter genus, and not to the recent *Ogotona* (*Lagomys*). The text makes no mention of this rodent as occurring in the caves of Mentone, so that further confirmation seemed desirable. This has now been obtained in the most satisfactory manner, Professor Boule having found *Prolagus* in the "Grotte du Prince," near Mentone. In his preliminary notice on the results of the excavations,[2] this rodent is stated to occur together with the rabbit, etc., in strata underlying an Upper Quaternary fauna (*Rhinoceros tichorhinus*, reindeer, ibex, marmot, etc.), and resting on deposits containing a Lower Quaternary fauna (*Elephas antiquus, Rhinoceros Mercki, Hippopotamus*).

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[1] Sowerby, in Murchison's Silur. Syst., p. 609, pl. v, fig. 6.

[2] A. Risso, Hist. Natur. des princ. prod. de l'Europe mérid., vol. i, pp. 151, 152 (1826).

[3] E. Rivière, "La Grotte Lympia": C. R. Paris, vol. xciv, p. 1264 (1882).

The question as to the specific identity of all these remains of *Prolagus* from different localities must be left to future investigation; the evidence from some of the continental deposits is for the present so scanty that it is only just sufficient to ensure the generic determination, even that remaining still somewhat doubtful with regard to *Lagomys* from the Nice deposits.

From the discovery of *Prolagus* at Barcelona, Depéret inferred a continental origin of the Corsican and Sardinian forms. "Il est dès maintenant facile de suivre l'émigration géologique de ce rongeur depuis le Pliocène de Perpignan, en passant par le Quaternaire ancien de Barcelone, jusqu'au Quaternaire récent de Corse et Sardaigne."[3] It remains, however, to be seen whether all the insular Pleistocene deposits containing the *Prolagus* belong to the upper and all the continental to the lower stage of that period. It is also to be borne in mind that not all of the latter deposits seem to have been continental in origin. All of them, from Gibraltar to Mentone, are on or near the seashore; some of the bone breccias, e.g., Gibraltar, Antibes, Cette, being situated on promontories, which have only recently become connected, or more probably reconnected, with the adjacent continent, and, as in the case of the more eastern ones, may have been part of Corsica, or rather of the 'Tyrrhenis,' to use a term which implies a larger area.

Depéret assumes that the *Prolagus* did not exist in Corsica and Sardinia before recent Pleistocene times. Since it existed at Casino, viz., during a period when Corsica and Sardinia, for all we know, were connected with one or more parts of Southern Europe, there is every likelihood that during that period of the maximum of regression of the Mediterranean, it likewise flourished in Corsica and Sardinia.

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[1] E. Rivière, "Paléoethnologie." "De l'Antiquité de l'Homme dans les Alpes-Maritimes," pl. xvii (Faune des grottes de Menton), fig. 10, Paris (1878)—1887.

[2] Marcellin Boule, "Chronologie de la Grotte du Prince près de Menton": C. R. Paris, vol. cxxxviii, No. 2, pp. 104–106 (1904).

[3] Op. cit., p. 886.

II. *Rhagamys orthodon (Hensel), Murine Rodent from the Pleistocene of Sardinia, Corsica, and Tavolara.*

RHAGAMYS ORTHODON (Hensel).

Mus orthodon, Hensel, Zeitschr. deutsch. geol. Ges., vol. viii, pp. 281–289, pl. xiii, figs. 6–10 (1856); Forsyth Major, Atti Soc. Tosc. Sc. Nat., Proc. Verb., vol. iv, pp. 139–145 (1884); Trouessart, Cat. Mammalium, p. 477 (1898–99); Barrett-Hamilton, Proc. Zool. Soc. London, 1900, pp. 421, 422.

In an appendix to his valuable paper "On geographical and individual variation in *Mus sylvaticus* and its Allies," Major Barrett-Hamilton has a note on *Mus orthodon*, which opens with the sentence here reported: "In dealing with *Mus sylvaticus*, I must allude also to *Mus orthodon, which is believed to be very closely allied to it*" (italics mine), "and the skulls and teeth of which in the British Museum collection I have examined."[1] From his synonymy, where we read "(aff. *Muri sylvatico*, fide C. I. Forsyth Major, P.-verb. Soc. Tosc., 1888, p. 129)," it results that I am supposed to be the believer in the very close relation of the fossil with *Mus sylvaticus*. The writer assumes the easy task to show from my own specimens that this very close relation does not exist. The "aff. *Muri sylvatico* . . ." is taken from Trouessart's Catalogue. Neither of my two friends has taken the trouble to understand my detailed description (in Italian) of the fossil in question.

In the original description of *Mus orthodon*, Hensel had arrived at the conclusion that his group of the *Ratten* (*Mus decumanus, M. rattus, M. musculus*) is in some respects intermediate between the fossil and his group of the *Mäuse* (*Mus sylvaticus, M. agrarius, M. minutus*).[2] With more material at my disposal, I was able to show that some of the supposed differences of *Mus orthodon* from the group *Mäuse* did not exist, so that, on a comparison of the fossil with the two groups of European species of *Mus*, it is with the group comprising *Mus sylvaticus, M. agrarius*, and *M. minutus* that *M. orthodon* has the greater affinities. It agrees with this group in the following points:—

(1) Presence of a postero-internal cusp (c'' of Hensel's diagram) in the upper molars.[3]

(2) In m_1 having a greater number of cusps than in the group *Ratten*, in which latter the odd anterior cusp is always missing.[4]

(3) In the pattern of the worn teeth, and

(4) In the number and position of their roots the fossil is likewise more related to the group *Mäuse*.[5]

The peculiar characters of the fossil are clearly proved:—

(1) From my lengthened description of the pattern of the molars.

(2) From their hypselodonty.[6]

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[1] Op. cit., p. 421.
[2] Op. cit., p. 289.
[3] Op. cit., p. 44.
[4] Ibid.
[5] Op. cit., pp. 44, 45.
[6] Op. cit., p. 145.

(3) From the peculiar thickness of the enamel layer.[1]

(4) From the more vertical position of the molar tubercles, whence the specific name given by Hensel.[2]

I am, and have always been, so much impressed with the importance to be attached to these peculiar characters of the fossil species, that I deem it necessary to raise it to generic rank.

III. *The Vole from the Pleistocene of Sardinia, Corsica, and Tavolara.*

ARVICOLA (TYRRHENICOLA) HENSELI, Maj.

"Campagnol de Cette, de Corse et de Sardaigne," p.p. Cuvier, Oss. foss., vol. iv, pp. 202, 205, 225, pl. xiv, fig. 7; pl. xv, fig. 29; vol. v, pt. 1, p. 54 (1823).

Hypudæus brecciensis, p.p. Giebel, Fauna der Vorwelt, vol. i, p. 88 (1847).

Arvicola ambiguus, Hensel, Zeitschr. deutsch. geol. Ges., vol. vii, p. 469, pl. xxv, figs. 3, 8, 9 (1855).

Arvicola Henseli, Forsyth Major, Atti Soc. Tosc. Sc. Nat., Proc. Verb., vol. iii, pp. 126, 127 (1882); id., Kosmos, vol. vii, p. 6 (1883); Lydekker, Cat. Foss. Mamm. Brit. Mus., vol. v, p. 322 (1887); Forsyth Major, in De Stefani, "Sul Fosfato di Calce della Sardegna," Atti R. Accad. Georgofili, vol. xiv, p. 11 (of author's copy) (1891).

"*Arvicola* groupe d'*amphibius*," Depéret, Ann. Soc. Linn. Lyon, vol. xliv, p. 122 (1897).

Cuvier was of opinion that the voles occurring in the breccias of Cette, Corsica, and Sardinia are all of one species; hence the specific name *Arvicola brecciensis* given to them by Giebel. Hensel proposed for the vole from Bonaria (Sardinia) the name *A. ambiguus*, which is preoccupied by Pomel's *A. ambiguus* (= *Dicrostonyx torquatus*). From a comparison of the figure of the Cette vole in the "Ossements fossiles" (pl. xiv, fig. 25) with my specimens from Toga (Corsica) and Sardinian localities, I inferred the distinctness of the continental form from that of the islands. The former being the first described (by Cuvier), the name *brecciensis* remains for the vole from Cette. Having since had, through Professor Boule's courtesy, the opportunity of examining the original of Cuvier's figure of the teeth from Cette, I was able to confirm the distinctness of the continental from the insular species. The former appears to be identical with some jaws which I have worked out of the Gibraltar breccia, and belongs to the subgenus *Microtus*.

The lower anterior molar (m_1) of the insular fossil vole has not more than three closed triangles,[3] a character which at once excludes the genus *Microtus*, in the restricted sense in which I have recently used this generic term, and places it within the genus *Arvicola*.

The complication of the anterior loop in the m_1 of the fossil, and the confluence of the two anterior triangles of m_2, both of which characters are features of the subgenus *Pitymys*, show that the fossil is more closely allied to *Pitymys* than to the subgenus *Arvicola*

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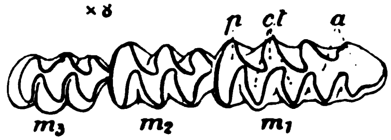
[1] Ibid.

[2] Ibid.

[3] I have found it convenient, in describing the molar teeth of voles, to adopt some terms used by American zoologists, for which see Gerrit S. Miller, jun., "Genera and Subgenera of Voles and Lemmings," North American Fauna, No. 12, Washington, 1896.

(*A. terrestris*, *A. amphibius*, etc.). There is a further agreement of *A. Henseli* with several members of the subgenus *Pitymys*, as at present understood, in some cranial characters. The skull is arched longitudinally, with backward shelving of the occipital; it is throughout rather high, but especially so the subcylindrical brain-case. The group of recent species of *Pitymys*, which agree with the fossil in these characters, are represented by *Arvicola incertus*, Gerbe nec Selys (South-eastern France), *A. ibericus*, Gerbe (Spain), *A. lusitanicus*, Gerbe (Portugal), *A. nebrodensis*, Mina-Palumbo (Sicily), a new species from the province of Lecce (South-eastern Italy), *A. Thomasi*, Barr.-Ham. (Montenegro), and a new species (*A. Savii*, Winge nec Selys) from Greece.



Arvicola (*Tyrrhenicola*) *Henseli*, Maj.
From the ossiferous breccia of S. Giovanneddu n. Iglesias (S.W. Sardinia).
Upper view of the left lower molars (enlarged, × 8).
p. posterior transverse loop; *c.t.* closed triangles; *a.* anterior loop.

A. Henseli has, however, several cranial and dental characters of its own which have induced me to place it in a separate subgenus (*Tyrrhenicola*). The nasals slope away anteriorly, more than in any other known species; they are also much longer. The whole of the anterior facial portion of the skull is remarkably elongate, and comparatively narrow; accordingly the foramina incisiva, which are provided with sharp margins, are remarkable for their length. The superciliary ridges unite in the middle line to form a sharp longitudinal crest. In the posterior basal portion of the skull the bones are crowded together, the mesopterygoid fossa is short and rather narrow, the posterior palatal fossæ very deep. The tympanal bullæ are comparatively small. Some of the preceding characters had already been pointed out by Cuvier,[1] as well as by Hensel,[2] who both had fragmentary crania from Sardinia at their disposal.

The incisors, as well as the molars, are weak when compared with the size of the skull.

All the molars are rootless throughout life. A peculiar feature of the molars, in which they approach the voles of the Upper Pliocene (*Mimomys*), which, however, are rooted, consists in the dentine spaces being more or less confluent with each other, so that, strictly speaking, there are no absolutely closed triangles. This character has been much exaggerated in the figures of the vole from Sardinia published by Hensel,[3] more especially in the two anterior lower molars. It is a general feature of the molars of all young voles.

[1] Op. cit., p. 205.
[2] Op. cit., pp. 471, 472, 475.
[3] Op. cit., pl. xxv, figs. 3*a*, *b*.

The following *dimensions in millimetres* are taken from specimens collected by myself in the ossiferous breccia of Monte San Giovanni, near Iglesias (South-west Sardinia).

	Cranium (B.M. M. 8156).	Imperf. cranium (B.M. M. 3488).	Mandibular rami (B.M. M. 3488).		
Basilar length	27	—			
Length of nasalia	10·5	—			
Length of foramina incisiva ...	7·1	7·4			
Length of diastema	10·1	10			
Fronto-palatal height above m_2	—	11·7			
The same, including the tooth ...	11·9	12·2			
Length of upper molar series ...	7·2	6·9	*h*	*i*	*k*
Length of lower molar series ...	—	—	7·2	6·8	6·5

In five upper jaws (M. 3488*c*, *d*, *e*, *f*, and *g*) the length of the upper molar series is respectively 6·9, 6·8, 6·5, 6·5, 7·1. In nineteen upper jaws remaining in my hands, the length of the upper molar series varies from 6·3 to 7·3. These two extremes are represented by only one specimen each. The remaining seventeen have the following dimensions:—Three, 6·4; three, 6·5; three, 6·6; five, 6·7; one, 6·8; two, 7.

VI.—The occurrence of *Anthracomya Phillipsi* in the Durham Coalfield.

By John T. Stobbs, F.G.S.

THIS important Coal-measure zonal Lamellibranch has already been recorded from the Yorkshire and Nottingham Coalfield (Cadeby and Gedling Colliery respectively), the Lancashire Coalfield (Ardwick, Manchester), the North Staffordshire Coalfield generally, the Forest of Dean and Bristol Coalfields, the South Wales Coalfield; and in all these widely separated districts it is found at the top of that portion of the Coal-measures characterised by the presence of the most valuable seams of coal.

In North Staffordshire *Anthracomya Phillipsi*, at one part of its zone, is associated with *Carbonicola vinti*, and this horizon has been widely traced.[1] Now, *Carbonicola vinti* was first recorded by J. W. Kirkby from the Coal-measures near Hylton in the county of Durham, under the name of *Ancylus vinti*,[2] and being familiar with the occurrence of these two forms in North Staffordshire the writer felt that the Hylton section should be specially searched for *Anthracomya Phillipsi*. Accordingly, on 25th August last an opportunity was afforded him of visiting Kirkby's section, which he experienced no difficulty in recognising from Kirkby's description. The locality now threatens to attract a denser population, and it may be wise to give the position of the exposure with greater precision. It occurs on the left bank of the River Wear (lat. 54° 55′ 5″ N.; long. 1° 25′ 50″ W.), and is marked on the Geological Survey maps by a fault. It is true that the Coal-measures abut against the Permian yellow sands as sketched by Kirkby in the paper referred to, but there was not enough evidence at the section to determine whether this juxtaposition of Permians and Coal-measures represents a post-Permian fault or simply a steep bank-side of eroded Coal-measures against which the Permian Yellow Sands were deposited. The colliery workings, however, should definitely settle the matter.

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[1] Wheelton Hind: Quart. Journ. Geol. Soc., vol. lv, pp. 367–8.

[2] James W. Kirkby: Trans. Tyneside Nat. Field Club, vol. vi, pp. 220–225.

The following is the section of Coal-measures at this point:—

	ft.	in.
Grey laminated shale		
Dark shales with nodular bands of ironstone (*A. Phillipsi*, *C. vinti*, etc.)	3	0
Grey gritty shale	1	6
Grit	3	0
Laminated arenaceous shale	2	0 +

Kirkby gave the position of these beds as not much more than fifty or sixty feet from the top of the Coal-measures, but this datum-line is a very uncertain one, owing to the pre-Permian denudation of the Coal-measures in the great Northern Coalfield. The most satisfactory method is to fix the horizon with respect to one of the well-known coal-seams of the Durham Coalfield, and the writer is indebted to Mr. Mark Ford, of Washington Collieries, who is familiar with the ground in question, for the information that the Hutton seam lies almost flat at a depth of about 1,700 feet in this locality. The measures are at the surface, almost at the deepest part of the coal-basin.

From the ironstone bands the writer collected:—

Anthracomya Phillipsi (Will.). Abundant.
**Carbonicola vinti* (Kirkby). Abundant.
**Beyrichia arcuata*, Salt. Not common.
Carbonia sp. Not common.
Spirorbis sp. Not common.
**Neuropteris gigantea*, Sternb. Not rare.

Those marked with an asterisk were recorded by Kirkby, together with *Diplodus gibbosus*, Ag., and other fish-remains. In addition he mentions *Anthracomya acuta*. Dr. Wheelton Hind, however, is unacquainted with this species, and very curiously, after talking the matter over with Mr. John Ward, F.G.S., that gentleman showed the writer a specimen of the ironstone containing *C. vinti* given to him by Kirkby, and on the outside of the nodule, hitherto unrecognised, were numerous individuals of *A. Phillipsi*. There is no doubt, therefore, that Kirkby's *A. acuta* should have been referred to *A. Phillipsi*.

The interest of the discovery lies in the proof of the existence of the *Phillipsi*-zone near the top of the Coal-measures in the Durham Coalfield, and, so far as we may legitimately infer from the character of the immediately-overlying measures in other coalfields, that in all probability the pre-Permian denudation did not remove much of the Coal-measures that are of special commercial value, but, on the other hand, it has rendered the excellent coal-seams of that district much more accessible. The writer desires to thank Dr. Wheelton Hind for verifying the naming of the Lamellibranchs mentioned in this note; this discovery is the natural outcome and verification of principles laid down by him.

VII.—Recent Marine Clays at Kuchavelli, Ceylon.

By Ananda K. Coomáraswámy, B.Sc., F.L.S., F.G.S., Director of the Mineralogical Survey of Ceylon.

KUCHAVELLI is twenty-two miles north of Trincomalee on the east coast of Ceylon. Two miles south of Kuchavelli is the mouth of the Salape aru. On the right bank of this river, near the mouth, raised beach, consisting of shelly sandstone, is exposed. The sandstone is often full of marine shells, and there are also thick growths of oysters attached to upstanding masses of rock. The bed is from 6 inches to 2 feet in thickness, and is exposed about 1 foot above high-water mark, and stretches down the sloping bank between tide-marks. This is the ordinary raised beach of Ceylon, a deposit usually occurring at or below high-water mark, and now being continually eroded at numerous points on the coast of Ceylon where it is exposed (e.g. Bentota). This deposit will not now be further spoken of.

The Salape aru is really the name of the estuary of several rivers; proceeding up the river inland, the Matti aru is reached, a shallow river with alluvial banks eight or ten feet above the water on either side. Extensive sandbanks are found on one side or the other of the river, alternating on the meanders with places where erosion is in progress. These banks are covered with marine shells, the large flat Placunas being most common. There are also found clayey nodules including marine shells, crabs, and it is said sometimes tortoises and fishes. The crabs are collected for use as medicine, being powdered and mixed with milk or water as a specific for diabetes. The crabs fetch from 25 cents to a rupee each, according to size.

The shell-covered sandbanks continue for some distance. The crab bed and source of the marine shells was detected *in situ* about a mile and a half from the mouth of the river and not far from a hill called Nachchiyar Malai. The bed is exposed in the river bank, and the section is roughly—

	ft.	ins.
1. Soil and alluvium	9	0
2. Crab bed—clay full of marine shells, nodules, etc.; in parts sandy	2	6
3. ? More sandy beds underlying the clay.		

Nearly all the shells common on the sandbanks, as well as a crab nodule, were found *in situ*. The top of the fossiliferous clay is probably about one foot or less above sea-level, and the fossils occur chiefly in the lower part and have to be dug out from below water-level. Beside the shells, etc., small pieces of wood are common in the clay, and crystals of selenite also occur. It is simply crowded with the flat Placunas (?).

In the Colombo Museum are a number of fossils from Palantiar, the exact situation of which I am uncertain. The crabs are also said to be found at Mullaitivu, on the coast north of Kuchavelli.

The bed can hardly be described as ordinary raised beach, but occurs at the same level as the usual sandy raised beach, which it appears to replace rather than to over- or underlie.

⁂ We subjoin a note on Mr. Coomáraswámy's fossils, which have been most kindly examined by Mr. R. Bullen Newton, F.G.S.—Edit. Geol. Mag.

VIII.—NOTE ON SOME POST-TERTIARY MOLLUSCA FROM CEYLON.

By R. Bullen Newton, F.G.S., of the British Museum (Natural History).

SOME marine shells, associated with crab-remains,[1] Balani, and small thread-like annelid tubes, from the Post-Pliocene deposits of north-eastern Ceylon, have been entrusted to me for determination by Dr. H. Woodward, F.R.S. They were collected by Mr. A. K. Coomáraswámy, B.Sc., Director of the Mineralogical Survey of Ceylon, and his description of the deposits containing the fossils forms the preface of this communication. Lithologically it is observable that there are two sets of specimens—those that occur in hard, water-worn nodules of clay, and others that were obtained from soft, dark, clayey beds found *in sitú*. The fossils found in the clayey material may perhaps be rather older than those found in the nodules, but as two of the shells are common to each, viz. *Placuna placenta* and *Potamides fluviatilis*, it is certain that no great distinction in age is to be recognised.

An examination of the species represented in the collection goes to prove that they belong to the existing fauna of the Indian Ocean, being similar to the life which is found in the creeks and back-waters of that sea, and consequently bearing a littoral or an estuarine facies.

It is interesting to know of the presence of corresponding Post-Tertiary deposits crowded with shells forming the coastal areas of the Madras Presidency of India, particularly at Pondicherry, Cuddalore, Tangore, etc., for the history of which we are mainly indebted to the late Mr. H. F. Blanford (Mem. Geol. Surv. India, 1862, vol. iv, pt. 1, pp. 192, 193). So numerous are the mollusca of these beds that they are utilised by the natives for the manufacture of lime. From lists given by Mr. Blanford it is ascertained that these mainland deposits contain molluscan species identical with those found in Ceylon by Mr. Coomáraswámy, a fact which not only suggests a similarity of age, but also proves that the separation of Ceylon as an island can be referred to a very modern epoch of geological history.

The following is a list of shells found in the Post-Pliocene beds of Ceylon and their occurrence in the Madras deposits. These determinations have been made with the kind assistance of Mr. Edgar A. Smith, I.S.O. It is satisfactory to note also that the specimens have been presented to the Geological Department of the British Museum by the collector, A. K. Coomáraswámy, Esq., B.Sc., etc.

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[1] The small, nearly perfect crab has been determined by Dr. H. Woodward as *Macrophthalmus Latreillei* (Desmarest), the 'Medicine Crab' of the Chinese pharmacopœia (see Daniel Hanbury, "Notes on Chinese Materia Medica," Pharmaceutical Journal and Trans., July and August, 1860, and February, 1862, published separately by the author, February, 1862, Plough Court, Lombard Street, E.C.); and the chelate pincer as belonging to *Scylla serrata*, De Haan, the great Indian swimming crab. *M. Latreillei* is also found in the Post-Tertiary clays of southern China (Island of Hainan), and *S. serrata* has been reported from similar beds in the Philippine Islands.

	Ceylon.	Madras.
GASTROPODA.		
Telescopium telescopium (Linnæus)	x	x
Potamides fluviatilis, Potiez & Michaud	x	x
Purpura carinifera, Lamarck	x	x
Nassa ornata, Kiener	x	
Melongena pugilina (Born)	x	x
Natica sp.	x	
LAMELLIBRANCHIA.		
Scapharca rhombea (Born)	x	x
Arca sp.	x	
Placuna placenta (Linnæus)	x	x
Tapes undulata (Born)	x	
Tapes textrix (Chemnitz)	x	
Diplodonta cf. *oblonga*, Hanley	x	
Tellina sp.	x	
Dosinia salebrosa, Roemer	x	
Chione allied to *imbricata* (Sowerby)	x	x

REVIEWS.

I.—THE GEOLOGY OF CYPRUS.[1] By C. V. BELLAMY, M.I.C.E., F.G.S., late Director of Public Works in Cyprus, and A. J. JUKES-BROWNE, B.A., F.G.S., late of the Geological Survey of Great Britain.

IN the beginning of the present year, 1905, a geological map and letterpress key of the Island of Cyprus, compiled by Mr. C. V. Bellamy, late Director of Public Works, was published by Edward Stanford.[2] This was almost entirely the result of work done in the field, and has now been followed by a more detailed and comprehensive treatise on the same subject with Mr. A. J. Jukes-Browne as joint author. It could have been wished that both had appeared simultaneously to form one harmonious work, the several parts forming the complement of the other, in which case the few discrepancies and alterations which now exist would have been obviated. One of the most important additions in the newer work, and included in the sketch-map which forms its frontispiece, is the recording of an outcrop of a bed of later Pliocene age situated west of Myrtou in the Kerynia District. It is of considerable extent, and has yielded specimens of *Ostrea cochlear*, obtained by Mr. Nicolls, besides large numbers of Foraminifera, of which a list of 186 species identified by Mr. F. W. Millett is given in Appendix iii.

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[1] Plymouth, W. Brendon & Son, Ltd., 1905, and read before the Geological Society, 4th January, 1905.

[2] See notice in GEOL. MAG., March, 1905, pp. 117-126.

Although several memoirs, including an interesting account of the Larnaka Salt Lake by Mr. Bellamy, have appeared since Professor Gaudry's important work,[1] the two publications mentioned above form the first comprehensive treatise on the geology of the whole island published since the completion of the Trigonometrical Survey in 1882, and the authors are to be congratulated on the manner in which this has been performed. Mr. Jukes-Browne has not visited Cyprus, but, besides being jointly responsible for most of the opinions expressed, he has contributed "all the descriptions of the lithological composition and microscopical structure of rocks, as well as comments on the fossils and inferences as to the relative age of the several rock groups." On the other hand, Mr. Bellamy has had five years experience of the island, almost every corner of which he appears to have visited, and it must be mentioned that it was entirely due to his own individual enterprise that these geological labours were undertaken and brought to so successful an issue.

Roughly speaking, Cyprus may be said to be made up of a central mass of igneous mountains, the Northern or Kerynia Range of limestone hills bordered on either side by the 'Hummocks' (Kythræan Series), the generally hilly, white chalky country (Idalian Series), and the later deposits of which the Messaoria and coastline are chiefly composed. The descriptions of these various formations and their subdivisions and the recording of a number of outliers in different parts of the island give evidence throughout of the immense care and continual close observation which have been brought to bear on the subject. At the same time the work is by no means over-elaborated, nor does it contain unnecessary repetition of matters already fully entered into in more specialised memoirs; rather it is a comprehensive and concise summary of our knowledge up to date of the subject, which has been verified and corrected at first hand and further largely added to.

In connection with the alluvial plains some interesting and suggestive facts are given with regard to the raising of the general level of the Messaoria by means of the silt brought down by the streams and rivers from the mountains by which it is bordered in two directions. After the mention of several phenomena which help to prove this, we read (p. 49) that "This would yield as a mean rate of elevation of the surrounding country of, say, one foot in a hundred years." It is seemingly owing to this, in conjunction with the formation of sand-bars, that the eastern portion of the Messaoria has become the fertile corn land that it now is instead of remaining an inland extension of the Bay of Famagusta. That there have been analogous, though less extensive, alterations in other parts of the coastline during comparatively recent times, is suggested, we are told (p. 51), by a map published in 1579, in which several examples of these changes are indicated.

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[1] Published in 1862.

From earliest historical times Cyprus has known a continual change of ruler, owner, and occupier, and during its geological past it has been no less the scene of many and varied changes. In chapter viii we are given an interesting summary of the physical history of the island with maps showing the different aspects of Cyprus during two previous epochs. Its former connection with the mainland *viâ* the Karpas and the present Gulf of Iskanderun seems to be a fairly established fact.

One of the chief drawbacks to commercial enterprise on any large scale is the possible insecurity felt on account of Cyprus being in point of fact still a portion of the Ottoman Empire. However, setting this aside, we find as a result of scientific investigation that there is not the amount of inducement that might have been expected from the island's former reputation for great mineral wealth. The copper, which was worked by the Phœnicians and probably also by the Romans, does not appear to have been rediscovered in any great amount. A few other minerals occur, but apparently only in small quantities. In the chapter (ix, pp. 57–66) devoted to the economics of the island is refuted an error, formerly supported by no less an authority than M. Gaudry, to the effect that Cyprus was devoid of marble. In fact, we read on p. 57 that "It is now placed beyond all doubt that the beds of marble are of great extent, and the varieties numerous and frequently beautiful." Further, a number of specimens were sent to a sculptor and expert in marble, whose verdict proclaimed them to be of excellent quality, one being "equal to the best Parian marble." We believe that this discovery is entirely due to Mr. Bellamy. These marbles are all found in the Trypanian Rocks, which are almost entirely confined to the Kerynia Range, which also produces lime of a very fine description. From the Idalian Series alabaster is obtained and also gypsum, which is exported in considerable quantity. Building and paving-stone of various qualities occur in many parts of the island, the best being supplied by the shelly limestones of the Pliocene and Pleistocene beds. It was perhaps considered to be beyond the scope of this work, but at any rate we are not told whether these marbles, or any other of the mineral products, are likely to become of any very great commercial importance to the island in the future.

The transliteration of Greek into English is frequently a stumbling-block, and in this case it could be wished that there were a little more uniformity in the spelling of place-names, which frequently does not agree in the map and its key with that in the work under discussion, and does not even always correspond in the one publication. This is apt to give a suggestion of carelessness to be deprecated in a scientific work. However, this is a small matter and can hardly detract from the usefulness of this valuable and much needed work on the geology of Cyprus. D. M. A. B.

II.—EXTINCT ANIMALS. By E. RAY LANKESTER, M.A., LL.D., F.R.S., Director of the Natural History Department, British Museum. 8vo; pp. xxiv and 332, with 218 illustrations. (London: Archibald Constable & Co., Ltd. Price 7*s*. 6*d*. net.)

IT is a fortunate circumstance that the lectures delivered at the Royal Institution orally, with lantern illustrations, last Christmas, by Professor Ray Lankester, should, before another Christmas has yet arrived, be printed as a book, not only admirably suited to boys and girls, but for men and women also, with an abundant amount of illustrations in the text calculated to make it most attractive to the general reader.

Everyone will recollect the droll creatures so cleverly invented by Tenniel for "Alice in Wonderland," and one cannot help feeling that with many of Professor Lankester's monsters the children of to-day will be equally delighted. What, for instance, could be more quaint than the probable appearance of *Iguanodon* (p. 198), or the dear little *Arsinöitherium* (p. 153). Nor is the long-jawed Mastodon (*Tetrabelodon*) without a certain comic Christmas aspect (p. 119). The artist has, by accident, put the prehensile tip of the animal's proboscis *below*, instead of above, the nasal aperture, but this is the only serious slip we have noticed, and for a picture-book of extinct animals it is the best of its kind we have ever seen. The book, however, is much more than a book of pictures; it is full of information presented in an agreeable form for the non-scientific public, and is very much up to date. The only new animal which came over from America too late to find a place in its pages is Mr. Carnegie's *Diplodocus*, which one must go to the British Museum to see.

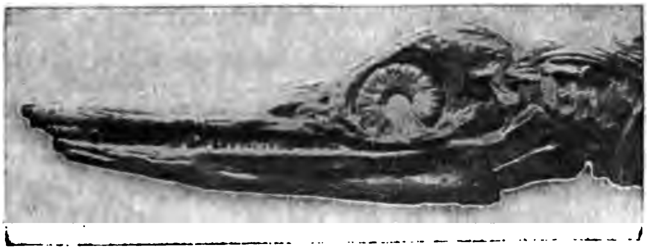

FIG. 1.—Head of an *Ichthyosaurus*, from the Liassic rocks of Lyme Regis, in the Natural History Museum. The head is 3 feet 6 inches long.

Professor Lankester, among many other attractions, introduces his audience to a fascinating skull of an extinct monster which he remembered to have seen in his own youthful days in the Natural History Museum, "then in a remote part of London called Bloomsbury, but now in Cromwell Road, Kensington. It is the head of an *Ichthyosaurus* dug out of the rock in the South of England, at Lyme Regis, many years ago. The eye is peculiarly well-preserved.

The circle of bony plates, similar to those found in the eyes of birds, gives an expression of interest which few fossils can boast of" (p. 6).

The author tells of the 'Mammoth' whose skeleton was found in frozen soil in Siberia, by Adams, a century ago, now in the St. Petersburg Museum, upon whose bones, when first discovered, the flesh and skin were still preserved, but much of the soft parts had been devoured by the wolves, foxes, and other animals, who feasted on *preserved meat* for weeks, before the skeleton (with what little remained of the soft parts) was transported from the banks of the Lena to St. Petersburg.

But the latest discovery of a Siberian Mammoth was made in 1901, in the province of Jakutsk, where an entire skeleton of *Elephas primigenius*, clothed in flesh, hair, and hide, was unearthed on the banks of the Beresowka, a tributary of the Kolyma, and was successfully carried to St. Petersburg, the skeleton being set up in the Academy Museum, and also the skin, which has been prepared by a taxidermist, softened and stuffed, like that of a modern animal, in the attitude of death, surrounded by the morass in which it made its last struggle (see Geol. Mag., 1903, pp. 361–363, Pl. XVIII).

A considerable space is devoted to the recent discoveries made by Professor Amalitzky, of Warsaw, of a whole series of skeletons of Theromorph reptiles (closely similar to those from the rocks of Cape Colony) from the banks of the Northern Dwina, near Archangel in North Russia. He has not yet finished his excavations nor published the results, but has allowed Professor Lankester to refer to them and to show the photographs. The remains were found in immense nodular masses harder than the soft Permian strata forming the cliffs in which they lie imbedded. These nodules had been long used for mending the roads, and when broken open displayed the bones of reptiles. Professor Amalitzky had them dug out and conveyed to the University of Warsaw, where they are being gradually worked out and mounted, the Imperial Academy of St. Petersburg allowing him a thousand pounds a year towards the expenses. There were many skeletons of *Pariasaurus*, like that obtained by Professor Seeley from the Karroo Beds in South Africa, and several of a huge carnivorous reptile (*Inostransevia*) allied to *Lycosaurus*, also found in Cape Colony.

Professor Lankester points out the interesting fact of the presence, even in these early Triassic times, of the two types, the carnivorous and herbivorous dwelling together, the bloodsucker and its victim, just as in Jurassic times the two types of Dinosauria occur, and at the present day the Carnivora and Herbivora exist side by side in Africa and India and indeed over a far wider extent of the earth.

The lecturer gives an interesting account of the Old Silurian and Devonian fishes about which he formerly contributed a monograph to the Palæontographical Society. He also discourses upon the Pearly Nautilus, the Cuttle-fish, and their ancient allies the Belemnites and Ammonites, many figures of which are given. The Trilobites, and next the giant Merostomata, the *Pterygotus*, *Eurypterus*, *Stylonurus*, *Slimonia*, and their relatives the King-crabs and Scorpions, occupy the field, and we see how forms adapted for an aquatic existence may have their external leaf-like breathing organs transformed into internal tracheæ suitable for air-breathing terrestrial dwellers.

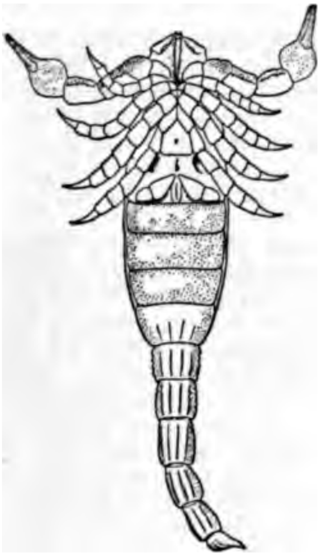

FIG. 2.

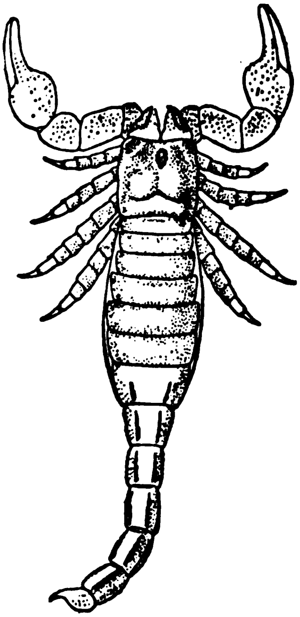

FIG. 3.

FIG. 2.—Restored figure of the Scotch Silurian Scorpion (*Palæophonus Hunteri*), seen from below, to show the bases of the legs.

FIG. 3.—Restored figure of the Silurian Scorpion from Gothland (*Palæophonus nuncius*), seen from above.

One is astonished to find amid a changing world, in which whole races of animals have appeared and disappeared over and over again, that such simple creatures as king-crabs and scorpions date back their ancestors to the Silurian period in Europe and America, and still form a part of the living population of the world, the scorpions dwelling in dry desert countries widely distributed over the old and new world, the king-crabs along the Atlantic American seaboard, and also in the Indian, China, and Japan seas.

As to the size of animals, the lecturer reminds us that the ancestors of the elephant, the horse, and other living types were quite small forms; and that the hugest of huge reptiles, the extinct *Diplodocus*, 80 feet in length, is exceeded in bulk by the Right Whale, belonging to the highest existing class, the Mammalia.

We predict for this book many readers, and, as a result, many more visitors to the Natural History Museum, over which the author, Professor Lankester, presides.

III.—EGYPTIAN GEOLOGICAL SURVEY.

THE TOPOGRAPHY AND GEOLOGY OF THE FAYÛM PROVINCE OF EGYPT. By H. J. L. BEADNELL, F.G.S., F.R.G.S. 4to; pp. 102, plates i–xvi from photographs, 2 maps, 6 sections, and 10 figures in the text. (Cairo: National Printing Department, 1905.)

THE Province of the Fayûm is deeply interesting alike to the archæologist and the geologist. It occupies a large circular depression in the Lybian Desert, situated some 50 miles south-west of Cairo, and immediately west of that part of the Nile Valley lying between Kafr el Ayat and Feshn. The depression, which, roughly speaking, has an area of about 12,000 square kilometres, comprises within it three distinct parts—(1) cultivated land, (2) lake, and (3) desert.

(1) The cultivated land has an area of about 1,800 square kilometres, and, with the exception of the lake and part of the Wadi Rayan, it occupies the lowest part of the depression. This region is everywhere covered with alluvial soil, identical for the most part with the river alluvium of the Nile Valley, and is bounded by the desert on the south and east sides, and by the lake, Birket el Qurûn, on the north-west. It forms a more or less level plain, from which the ground slopes gently away, on the north side towards the lake. The Fayûm is directly connected with the Nile Valley by a narrow strip of low ground, a natural passage through the desert separating the Nile Valley and the Fayûm depression. Through this gap runs the natural canal known as the Bahr Yusef, which is the sole source of water in the Fayûm, irrigating the entire district. Once within the Fayûm the Bahr Yusef gives off numerous subsidiary canals which traverse the country in all directions, constantly splitting up into smaller branches until the water supply is divided throughout the whole area, finally draining into the Birket el Qurûn lake, the surface of which is now 44 metres below the level of the Mediterranean. There are two deep dry depressions to the south-west known as the Wadi Rayan and the Wadi Muéla; these have been examined by Mr. Beadnell with the idea of possibly utilising them in connection with a Nile reservoir.

(2) The present lake, which is from 80 to 90 square miles in extent, represents the existing remnant of the once celebrated Lake Moeris, which, in the reign of Amenemhat I and his successors of the Twelfth Dynasty, covered a large part of the floor of the Fayûm depression, and was converted by them into an artificially controlled sheet of water and used as a regulator of excessively high and low Nile floods in connection with the irrigation of the Nile Valley. The lake is now greatly reduced in size; in prehistoric times it must have been of immense extent—Mr. Beadnell thinks probably ten times the size of the modern Birket el Qurûn—for lacustrine deposits showing approximately the actual limits of the ancient Fayûm lake can be traced over wide areas of now barren desert.

(3) The desert region to the north of the lake is composed of beds of Middle and Upper Eocene age, forming a series of escarpments. It was here, within the past four years, that the most surprising results have been obtained by the palæontologist, almost surpassing in interest the truly remarkable discoveries which had rewarded the earlier labours of Marsh, Osborne, Scott, and others in North America. When Schweinfurth crossed the region in 1879 he found fossil bones, which were determined by Dames to be the remains of Cetacea of the genus *Zeuglodon*. These appear to have been the earliest vertebrates obtained from the Fayûm. In April, 1901, some of the localities, previously noticed by Mr. Beadnell in 1898 to be bone-bearing, were revisited by him, in company with Dr. C. W. Andrews, of the British Museum, then spending the winter in Egypt,[1] when additional evidence of fossil vertebrates was met with. A new locality was also discovered further north (where the outcrop of the bone-beds was crossed), and a considerable number of mammalian and reptilian bones was observed exposed at the surface, including remains of Sirenians, *Zeuglodon*, etc., the most important land mammalia being *Palæomastodon Beadnelli*, *Mœritherium Lyonsi*, *Barytherium grave*,[2] etc. Later on the remarkable new ungulate *Arsinöitherium Zitteli*, Beadn., was discovered by Mr. Beadnell (see Geol. Mag., 1903, pp. 529–532, Pls. XXIII and XXIV) with many others. Important and wonderful as these discoveries are, their value is greatly enhanced by the extraordinary completeness of the stratigraphical record exhibited in the very clearly exposed and regular series of deposits laid bare on the flanking cliffs and escarpments on the northern side of the Fayûm, of which the author gives a large number of sections with details of each separate bed. Thus we commence with a magnificent exposure of Middle Eocene (Parisian) strata, having a thickness of 1,300 feet, yielding Nummulites, Mollusca, fish-remains, and species of *Zeuglodon* with remarkably primitive dentition, and accompanying these, remains of a vertebrate land-fauna. Then follows the Upper Eocene (Bartonian), 830 feet in thickness, which has yielded abundance of vertebrate remains, the commonest being *Palæomastodon*, *Arsinöitherium*, *Mœritherium*, and Chelonians.[3] Still, in ascending order one meets with Oligocene (Tongrian) beds with a thickness of 100 feet of fluvio-marine beds, containing also silicified tree trunks in great abundance, with a sheet of hard basalt at the top. The youngest beds are gravel terraces and lacustrine clays, deposited by the ever-diminishing waters of the

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[1] Dr. Andrews subsequently paid three other visits to Egypt, and the results of his collections in the Fayûm, and of duplicate specimens contributed by the Survey, may now be seen in the fine series of objects exhibited in the cases of the Geological Department (Natural History), Cromwell Road. We are glad to learn that a Catalogue by Dr. Andrews, published under the joint auspices of the Trustees of the British Museum and the Survey Department of Egypt, will shortly appear, with figures and descriptions of the fossil vertebrates of this remarkable region.

[2] See Geol. Mag., 1901, pp. 400–409 and 436–444; 1902, pp. 291–295 and 433–439; and also on the Geology, 1901, op. cit., pp. 540–546.

[3] See paper by Dr. C. W. Andrews, Geol. Mag., 1903, pp. 337–343.

lake (Birket el Qurûn), also sands blown from the desert, and alluvial deposits.

"In a thickness of 700 metres (2,266 feet) these beds include every kind of sedimentary deposit—limestones, marls, clays, sandstones, sands, and gravels, forming an ever-changing succession of rocks, varying considerably in hardness and capacity for withstanding the agents of denudation. It is not too much to say that the coming into existence of the Fayûm, with its plains, low-lying depressions, precipitous cliffs and escarpments, was largely dependent on the nature of this variable series of deposits" (p. 15), out of which this hollow has been carved.

In reference to the origin of the Fayûm, Dr. Blanckenhorn describes it as a triangular depression *bounded on all sides by faults*, the position of which he shows on a map accompanying his paper.[1] "As these fault-lines lie for the most part within the area covered by the alluvial deposits and the waters of the lake, it is not easy, for want of exposures, to disprove their existence. But the fault along the east side follows the junction-line between the desert and the cultivated lands. Along this line everywhere the marls and limestones of the Ravine-beds pass regularly from the desert under the cultivated lands without any sort of break or dislocation, whilst an examination of the desert ridge to the east disproves the existence of any faulting on the desert side." "A few kilometres to the west the same beds appear in the ravine of El Bats, proving their continuity *under the cultivated alluvium* in this direction." The author deals with all the other faults propounded by Dr. Blanckenhorn, and concludes, after careful examination, that no evidence in favour of the existence of such faults was met with, and that everywhere the strata occupy their normal undisturbed level stratigraphical position (pp. 30 and 31).

"No evidence has as yet been met with," says Mr. Beadnell, "which would suggest that earth-movements have played any important part in the formation of the Fayûm depression. In fact, an examination of the desert margin conclusively proves that the depression has been cut out through the action of ordinary subaerial denuding agents" (p. 29).

The author pictures the condition of the Fayûm in Eocene times, and suggests that a great river flowed in a north-easterly direction along the line of the Baharia Oasis from a well-wooded continental area hundreds of miles to the south, carrying along with it in flood-time vast masses of matted rafts of forest trees, and bearing seawards the carcases of those curious Eocene animals the remains of which are so abundant in the Fayûm of to-day.

The memoir is distinctly in advance of its predecessors both in the printing and in the quality of its illustrations, which have been very carefully executed; the frontispiece, representing the Bahr Yusef at Lahun, before entering the Fayûm, is an excellent picture, and the plate (x) of the El Qatrani range, showing the magnificent basalt-capped cliffs, is also very good. The plate of the isolated sand-dune near Gar el Gehannem (pl. xv) illustrates the difficulties which often impede the traveller in crossing such desert tracks, some of these dunes being practically impassable by caravans for miles.

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[1] Blanckenhorn, "Geologie Aegyptens," Berlin, 1901, pt. iv, pp. 339–344.

Of the curious blocks of sandstone, pierced by numerous borings, we shall have something more to say on another occasion. They appear to be the exact replica of specimens brought home from Lake Tanganyika by Mr. J. E. S. Moore.

The maps and sections are most excellent. We congratulate the author and Captain H. G. Lyons, F.G.S., the Director General of the Surveys Department, on this most admirably executed memoir.

REPORTS AND PROCEEDINGS.

British Association for the Advancement of Science. Cape Town, South Africa, August 16th, 1905.

Address to the Geological Section (C) by Professor H. A. Miers, M.A., D.Sc., F.R.S., President of the Section.

(*Concluded from the October Number, p.* 478.)

Supersaturated Solutions.

I DO not myself see how we can do otherwise than apply to the study of rock-magmas all that can be learnt from physical chemists concerning the behaviour of solutions, for though we cannot attain in laboratory experiments the high temperatures and great pressures at which rocks may have crystallised, there is no reason to believe that these introduce more than a difference of degree. The principles of equilibrium between the various crystallising components probably remain the same, whatever may be the temperatures and pressures at which they have solidified.

It must at the same time be confessed that most of the experiments upon which the modern theory of solutions has been built up have been conducted upon dilute solutions, whereas the problems of crystalline growth are concerned, not with dilute nor even with saturated solutions, but only with solutions which are supersaturated. There is some force in the objection of Doelter that the results of such experiments may not be directly applicable to crystallising slags.

For example, as I have already mentioned, doubt has been expressed in the case of silicate magmas, whether the substances in solution are the minerals about to crystallise or only their constituents; whether viscosity and supersaturation may not invert the theoretical order of their appearance; whether we are to take into account possible dissociation of the molecules or not; whether the presence of a common ion in these minerals is a factor which determines their mutual solubility. In fact, very little is known about the actual condition of the materials in a strong solution, although I do not know that there is any evidence available which forbids us to regard a solution about to crystallise as a mixture of liquids one of which is about to pass into the solid state.

But if little is known about the nature of strong and supersaturated solutions, a good deal may be learnt about their behaviour. Having complained that we need experiments in this field, I may perhaps be pardoned if I allude to some unpublished experiments of my own which relate to the general behaviour of crystallising liquids, and appear to me to explain two difficult problems in petrography. To such experiments the objection of Doelter does not apply.

The Metastable and Labile Conditions.

When a solution of any salt such as alum or sodium nitrate is allowed to crystallise at a uniform temperature the crystals will only grow so long as the solution is supersaturated; a crystal growing in the supersaturated solution will continue to do so until a condition of equilibrium is attained. If the solution be kept at rest and maintained at a constant temperature, the crystal will continue to concentrate the liquid around itself and to withdraw solid material, until by diffusion of the impoverished liquid the whole mass is ultimately reduced to saturation, equilibrium is established, and the crystal ceases to grow; but most saturated solutions are so viscous that a very long time is required before this point is reached. Prolonged and vigorous stirring is required if the supersaturation is to be completely relieved within, say, a day; without stirring, weeks may be required.

Further, it may be possible, as is well known, to keep a supersaturated solution in a sealed tube for years without change; and it is also possible to start crystallisation in such a liquid by dropping into it a crystal of the dissolved substance, or of one isomorphous with it, or sometimes by shaking it.

But it is, perhaps, not generally known that supersaturated solutions are of two sorts.

In 1897 Ostwald published some experiments upon supercooled liquids and supersaturated solutions, which were carried out with the object of showing how extraordinarily minute are the quantities of solid material capable of starting crystallisation in such liquids, but at the same time that they have a limit of size. He called attention to the radical difference which probably exists between the state of a saturated solution which cannot crystallise spontaneously and that of the more strongly supersaturated solution which can do so.

The former is one in which crystallisation can either take place spontaneously or can be induced by stirring or shaking, or a variety of causes: this Ostwald calls the *labile* state. The latter is one in which crystallisation can only take place if a solid crystal of the dissolved substance, or a fragment of one, is brought into contact with the liquid: this he calls the *metastable* state. It is highly probable that no amount of stirring or shaking, or introduction of foreign substances, can make the metastable liquid crystallise.

Until recently no attempt to ascertain the exact limit between the metastable and labile states, or even to establish the existence of such a limit, had been successful, and practically no attention has been paid to the difference between them. Tamman, who measures the velocity of crystallisation by counting the number of the centres of growth or nuclei which appear in a supersaturated solution, does not recognise any distinction between the two states.

During the present year a number of experiments carried on by Miss F. Isaac and myself upon the strength of solutions from which crystals are growing have shown that it is easy to determine the changing concentration of a cooling solution by an optical method, to show that it passes into the labile state, and to ascertain the temperature at which the transition occurs. We have found, for example, that a solution containing 48 per cent. of $NaNO_3$ is saturated at 26°, is metastable between 26° and 16°, and crystallises spontaneously below that temperature; one containing 52 per cent. of $NaNO_3$ is saturated at 44°, and becomes labile at 35°.

In the metastable state inoculation by a solid germ of the dissolved substance, or of one isomorphous with it, is *necessary* in order to cause the liquid to crystallise; in the labile condition solid germs may be spontaneously generated from the liquid. Take, for example, a test tube filled with a solution of sodium-nitrate containing 48 parts of the salt in 100 parts of solution, which is metastable at ordinary temperatures; if crystals make their appearance in this solution it will only be because the dust of the room contains minute particles of sodium-nitrate which fall into the tube, or because crystals are deposited where drops have evaporated near the surface, and accordingly the first crystals appear at the surface of the liquid, and grow there until they are large enough to fall to the bottom. I find that such a solution, if enclosed in a sealed tube so as to prevent access of germs and evaporation, cannot be made to crystallise above the temperature of 16°, although it is supersaturated at all temperatures below 26°.

Again, let a hot solution of the same strength containing 48 per cent. of the salt be allowed to cool down while being stirred. If dust containing $NaNO_3$ can be excluded, the liquid will not crystallise until the temperature falls to 16°, when the solution passes from the metastable to the labile condition. A cloud of nuclei will then form throughout the liquid, and each will proceed to grow as a separate crystal; the immediate effect is to reduce the liquid to the metastable state so that no more crystals are produced, but each of these continues to grow from the liquid with which it is in contact.

If dust be not excluded, crystals may make their appearance upon the surface of the liquid and will soon sink; but even though they be stirred about actively in the solution the liquid as a whole remains in the metastable state till a temperature somewhat below 16° is reached, when the labile region is entered and a cloud of new crystals makes its appearance.

It follows, therefore, that in a cooling supersaturated solution, from which germs have not been excluded, there are normally two periods of growth: one in which a comparatively small number of isolated crystals are growing regularly, and a subsequent period in which a shower of small crystals is produced. Only if the rate of cooling be sufficiently slow, or the stirring be sufficiently violent, to keep the liquid in the metastable condition will there be no second period, no sudden precipitation of nuclei.

These events take place in all the aqueous solutions which I have examined, and I am surprised that they have not been discovered before. They afford a possible explanation of two common features of igneous rocks, and of slags—namely, the growth of comparatively large and isolated porphyritic crystals, or phenocrysts, and the appearance of the same mineral at two or more different periods. The origin and the arrested growth of phenocrysts have generally been attributed to sudden change of temperature, of pressure, or of hydration, and no other plausible explanation has been given, although, as has been sometimes pointed out, they may occur in batholites where there is no independent evidence of such changes. Pirsson has recognised the utter impossibility of the ordinary theory, and has recently suggested that each mineral has its crystallisation interval during which it continues to grow, and that this is terminated by the increasing viscosity of the magma, which checks the supply of further material to the growing phenocrysts and establishes new centres of crystallisation. A similar explanation was adopted by Crosby for the quartz-porphyry of the Blue Hills. He expresses it by saying that owing to the increased viscosity the rate of cooling overtaxes the molecular flow, which cannot keep pace with the crystallisation. It is so difficult to find any satisfactory theory for the growth of phenocrysts that they have even been attributed to the effect of earthquake shocks.

Now in a silicate magma, in all probability, the temperature is sufficiently high to be that of the metastable condition, the rate of cooling sufficiently slow to keep the liquid in that condition for a considerable time, and the viscosity sufficiently great to prevent the growing crystals from sinking at once; we have, therefore, all the conditions favourable for the growth of *porphyritic* crystals; these must have generally originated throughout the liquid as spontaneous nuclei if the magma entered the labile state, or may have been started by inoculation or cooling at the margin if the magma as a whole remained in the metastable state. In the latter case suppose that further somewhat sudden cooling brings the magma to the labile condition, then there will be a sudden and spontaneous second growth of nuclei which will not be able to attain the dimensions of the porphyritic crystals; we have here all the conditions necessary for a *second generation* of one of the constituents of the rock.

It is not necessary, therefore, to suppose that changes of pressure played any very great part in these matters. I believe it will be found that considerations of temperature and solubility are far more important. Similarly, in the case of the salt deposits van 't Hoff came to the conclusion that practically the only effect of changes of pressure is to displace the temperature of formation of the various compounds and not to alter their order or their nature; he estimates that this displacement is comparable with that of the melting-points under the same agency, and in the case of the calcium-magnesium chlorides only amounts to a few thousandths of a degree for one atmosphere of pressure.

Perhaps when we can ascertain the temperature at which silicate magmas pass from the metastable to the labile condition we may use this knowledge to determine the exact temperature at which certain of their minerals crystallised.

Ordinary petrographical descriptions supply numerous examples of the difference between the metastable and labile conditions to anyone who will read them in the light of the suggestion which I have made; others are to be found in such experiments as those of Vogt or Doelter.

My own hope is that when more experiments have been made upon mixed *supersaturated* solutions it will be found that most, if not all, of the features of rock development are paralleled by the ordinary process of crystallisation, but that motion, supersaturation, and supercooling are most important factors.

The very similarity between the differentiation of the alumo-alkaline and ferro-magnesian minerals on a small scale in the rock, and that of the alumo-alkaline (or salic) and ferro-magnesian (or femic) rocks themselves on a large scale, points to some similarity of origin.

In order to avoid burdening this address with detail I have merely chosen the researches of van 't Hoff, Vogt, Doelter, and Heycock and Neville as illustrations of experimental work conducted on the lines of modern physical chemistry, and have omitted much that might have been mentioned; the valuable researches of Pelouze, Lagorio, Morozewicz, and Loevinson-Lessing, and the melting-point determinations of Joly I have not quoted, because they belong for the most part to an earlier period than that which I am considering, and have been discussed by Teall and other writers.

Many very interesting speculations I have passed over entirely, because my object has been to focus attention upon experimental evidence. I cannot help thinking that these speculations are often based upon chemical actions and equilibria that may be impossible; but we cannot criticise them for lack of evidence, and I return to my original statement that geology is only beginning to enter the experimental stage.

An earnest beginning is, however, being made. The researches on mineral and rock synthesis which I have already quoted are laying a solid foundation; and I see no reason why something of the sort which has been done by van t' Hoff and his collaborators for the aqueous deposits of Stassfurt should not ultimately be worked out for an igneous complex, though it may involve tenfold the labour and tenfold the time. We have already to welcome the establishment by the United States Geological Survey of a laboratory for the express purpose of applying to minerals and rocks the exact methods of modern physics and physical chemistry. The very suggestive research of Day and Allen upon the thermal properties of the felspars is a promise of the sort of work that may be expected from such laboratories.

I fear it will be only too evident to those who have given me their patience during this address that I approach the problems considered in it from the point of view, not of the geologist or the chemist, but of the crystallographer, to whom the birth and growth of crystals are a study in themselves. Whether we watch with the microscope a tiny crystal growing from a drop of solution, or contemplate with the imagination the stages by which the fiery lavas of past geological periods sank to rest and crystallised, we view the same process; it is the transformation of liquid into crystal. Not necessarily into a solid, for recent research shows that there is no dividing-line between liquid and solid; a plastic solid body may flow; a solid glass is only a supercooled liquid; witness, for example, the experiments of Adams on rocks and of Tamman on supercooled liquids. The real primary distinction is between crystalline and non-crystalline material, and there is even good reason to believe that some crystals are liquid without ceasing to be crystals.

The properties of most rocks, of metals, alloys, ice, and many other substances are due to the fact that they consist of crystals, and the importance of the study of the latter is now, I trust, being brought home alike to chemists, physicists, geologists, and engineers in connection with problems relating to the strength, the movements, the origin, and changes of what are usually called solids.

And so I close, as befits a student and teacher of crystallography, with the hope that renewed attention may be paid to this subject, and that it may attract the interest of many a keen intellect in South Africa. The higher scientific studies are now establishing themselves as an integral part of the educational and intellectual life of the country. This is in no small measure due to the South African Association; and we may hope that the visit of the British Association will be of some help to her younger sister in the task of diffusing a taste and an interest for the pure truths of science and the studies that they both hold dear.

CORRESPONDENCE.

THE TRIMINGHAM BLUFFS.

SIR.—As no stress was laid on the presence of *Belemnitella mucronata* in the Chalk at Trimingham, and we do not consider the erratics of that rock in the Cromer district to have made more than short journeys, we cannot agree with Mr. B. B. Woodward about the importance of the literature of the subject since 1882. One of us was acquainted with the general results of Mr. Brydone's work, but thought minute zonal information had no direct bearing on our objections to Mr. Clement Reid's hypothesis. That of a sea-stack, though less open to stricture, involves some serious difficulties which Mr. B. B. Woodward has apparently overlooked. Surely the majority of these masses at Trimingham cannot be 'stacks.' On the right of the reproduced photograph (Pl. XXII) boulder-clay can be seen underlying the chalk mass (E) at (F), and another one (C) at (D). Again, if (C) merely rests against (A), to form the roof to the tunnel (B) filled with boulder-clay, it must be an erratic, for sea-stacks are not generally mushroom-shaped. The small chalk mass further east, seen in 1900 (p. 399) but now washed away, must, we think, have been a boulder, while if the original eastern mass, which has met a similar fate, was a stack, the fact (more than once recorded in our notes) that the flint bands in it were fairly horizontal and those in the other sharply curved, was, to say the least of it, singular, for it would require the axis of flexure to have taken a very abnormal course. But if (A) and (C) form parts of one stack the position of the tunnel (B) is hardly less singular, for, instead of looking in the teeth of the waves, it takes a sheltered course more nearly parallel with the coastline. It is therefore highly improbable that any other mass than (A) can be a stack, and if so, it is curiously environed by great boulders. But if it be, what becomes of Mr. Reid's hypothesis? Did the advancing ice-sheet first 'ruck' up the chalk, then retreat to allow the sea to carve out a stack (and make a tunnel if (B) and (C) form one mass), and return to wrap it up in boulder-clay? Or was a pre-Glacial stack mercifully spared by the ice-sheet? In fact, the sea-stack hypothesis involves so many difficulties that Mr. Woodward must pardon us for suggesting the possibility of his having been misled in regard to the chalk in the headland being one mass with that in the platform. In a material like chalk, as we found at the arch, it is difficult to determine continuity or discontinuity, and equally so to trace bands of interrupted flints. But be this as it may, Mr. Woodward has discarded Mr. Clement Reid's hypothesis, and in so doing indirectly justifies our remark that it was out of place in a Survey memoir. To this we adhere, though it may cause "some surprise" to "students of East Anglian geology" (are they a zonal variety?). This is our reason: A Survey memoir is an official publication, which is inevitably invested with authority. It is also published, as the work is done, at the cost of the nation. We therefore hold that it should be a record of facts, not of hypotheses of a more or less tentative or dubious character: these find a proper home in the ordinary scientific periodicals. Thus no one could object to the appearance of Mr. Reid's hypothesis in this Magazine, but in the Cromer Memoir a mention of it with a reference would have sufficed.

T. G. Bonney.
E. Hill.

THE TRIMINGHAM CHALK.

Sir,—May I suggest a small innovation in your usual practice, which would be very grateful to your subscribers, namely, the reprinting of Mr. Brydone's remarkable paper in the Geological Magazine. This paper, to which Mr. B. B. Woodward has called timely notice, has virtually only been privately published, and the fact of its not being quoted by Professor Bonney and Mr. Hill may perhaps be thus explained, although it has been out for *five years*, and is specially quoted and utilized in so accessible a monograph as the portly Survey Memoir on the Cretaceous Rocks of Great Britain, published a year ago (op. cit., pp. 260–264), which also seems to have escaped the notice of the two authors just cited.

[I have procured a copy of Mr. R. M. Brydone's paper, dated August, 1900. It is a pamphlet of 16 pages, and was published separately by Dulau & Co. (price 1*s*.).]

I may add that in regard to Mr. C. Reid's argument and conclusion as to the Trimingham bluffs and their explanation, it is many years since, I think, I conclusively showed the impossibility of his theory, a fact also overlooked by the authors of the much criticised paper in your September number.

20, Collingham Place, Earls Court. Henry H. Howorth.
October 4th, 1905.

OBITUARY.

PROFESSOR BARON FERDINAND VON RICHTHOFEN.

Born May 5, 1833. Died October 6, 1905.

It is with much regret that we record the death of Baron Ferdinand von Richthofen, Professor of Geography in the Berlin University, and eminent alike as a geologist and geographer; who for the last seventeen years taught in that city, and of whom it has been said that there are few among living German geographers who are not proud to call themselves his pupils.

Born at Karlsruhe, Silesia, on 5th May, 1833, he studied first at Breslau, and afterwards at Berlin (1850–6), graduating in 1856. His first geological work was performed in the South Tyrol.

In 1860, with the rank of a Legation secretary, he joined Count Eulenburg's Prussian expedition as geologist, visiting Japan, China, and Siam; he then left the expedition at Siam and continued his travels in Java, Manila, the Philippines, Celebes, and Burma, spending some time in California and Nevada. In 1868 he went to Shanghai and explored for four years a large part of China, returning to Europe in 1872, to work out the results of his travels. The University of Bonn, after electing him to the Chair of Geography in 1875, allowed him to complete the first part of his great work on China before taking up his post in 1879. From Bonn he was transferred to Leipsic in 1883, and to Berlin in 1886, where he continued to lecture until the time of his death. It was by his advice that the German Government selected Kiao-chau as its naval base in the Far East, and have subsequently devoted themselves to the special development and exploration of the province of Shantung.

Baron Richthofen took an active part in the International Geological Congress held in London, September 17th, 1887. In the following year he was elected a Foreign Member of the Geological Society of London, and in 1892 he received the award of the Wollaston Medal from the Council of that Society. On the occasion of its presentation Sir A. Geikie, the President, said of Baron Richthofen's great work on the geology of China, "The massive volumes and splendid atlas which contain his account of China form one of the most important contributions ever made to geological literature" (Geol. Mag., 1892, p. 183). His lectures and writings amply testify to the intimate connection which exists between the sciences of geography and geology, and one is led to wonder how they were ever separated.

Baron Richthofen died on October 6th in his 73rd year. His loss will be felt wherever the sciences of geology and geography are cultivated.

MISCELLANEOUS.

RETIREMENT OF MR. HUGH J. LLEWELLYN BEADNELL, F.G.S.

WE regret to announce that Mr. Beadnell, who for nine years has been connected with the Geological Survey of Egypt, has just retired to take up other work in Egypt. He went direct from the Royal College of Science to Egypt when the Geological Survey of that country was established in 1896. In the Winter of 1896–7 he mapped various portions of the Nile Valley between Minia and Esna, and paid a flying visit to the extensive salt deposits in the Eastern Desert between Assiut and the Red Sea. The following Summer he took up the Abu Roash district, which had been described by Walther and Schweinfurth as a Cretaceous complex separated by faults from the surrounding Eocene: Mr. Beadnell's detailed examination showed, however, that the junction throughout was in reality an unconformable one, the faults being entirely within the Cretaceous beds. The following year the examination of the Libyan Desert oases was taken up, Baharia (western portion), Farafra, and Dakhla oases falling to his share. The most important results of this season's work included the discovery of Cenomanian beds in Baharia and extensive phosphatic deposits in Dakhla. The unconformity between Cretaceous and Eocene, found the previous Summer in Abu Roash, was proved to extend to Baharia.

In 1898 he commenced the examination of the Fayûm, though the work was temporarily suspended to complete parts of the Nile Valley further south. In 1901–4 work was continued at intervals in the Fayûm, and systematic excavations for fossil vertebrate remains were undertaken. During part of this time Dr. Andrews, of the British Museum (Natural History), was associated with Mr. Beadnell or encamped within a short distance, and their united labours resulted in the bringing to light nearly forty new genera and species of mammals and reptiles described and determined by Dr. Andrews. A very large collection of the remains of these animals is now exhibited in the Cairo Geological Museum, while a second representative collection has found a home in the British Museum (Natural History).

Among other districts Mr. Beadnell carried out topographical and geological work in Mogara, Wadi Natrun, Kharga Oasis, and the Nile Valley between Esna and Aswan.

On the Egyptian Geological Survey the work is by no means confined to geology, and geologists have to personally carry out a large part of the purely topographical work. He has been three times to the Sudan, spending altogether nearly a year in taking discharges on the White and Blue Niles and the Atbara River for the Egyptian Irrigation Department. He has on two occasions during the Summer months also been in charge of a section of the Revenue Survey.

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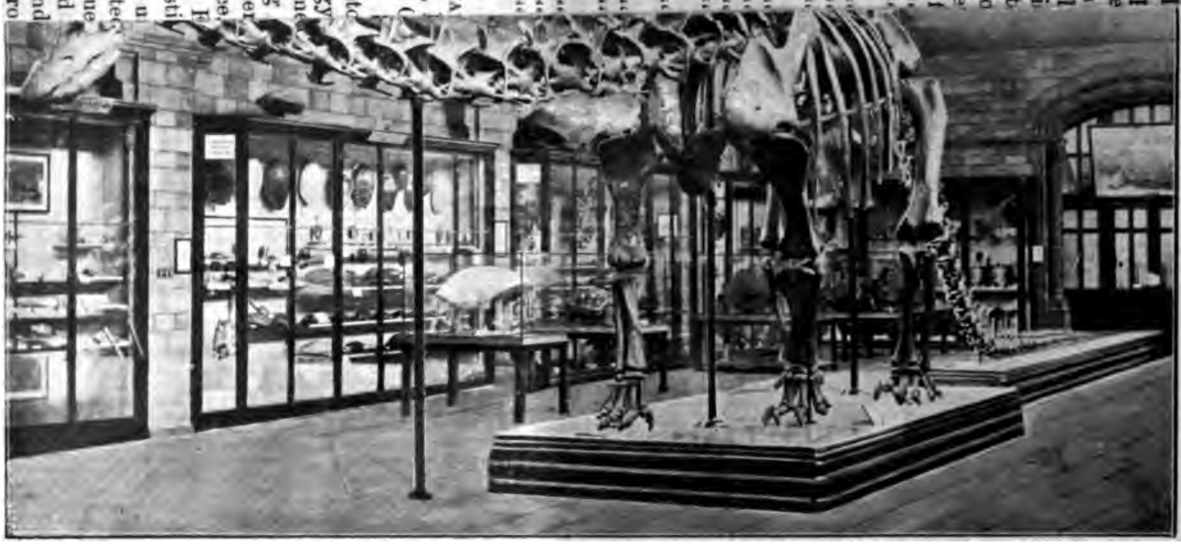

Reproduction of the skeleton of *Diplodocus Carnegiei.*

The original was obtained from the Jurassic of Wyoming, U.S.A. **This huge Dinosaurian reptile measures 80 feet in length and 14 feet in height. The cast is set up in the Natural History Museum, Cromwell Road, and was presented to the Trustees, May 12th, 1905, by Mr. Andrew Carnegie.**

[*From a photograph by Mr. J. I. Pigg.*]

THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE V. VOL. II.

No. XII.—DECEMBER, 1905.

ORIGINAL ARTICLES.

I.—Notes on the Geological History of the Victoria Falls.[1]

By G. W. Lamplugh, F.R.S.

IT is difficult for anyone standing on the brink of the Chasm, after having seen the placid flow of the Zambesi above the Falls, to believe that the fissure into which the river is so suddenly precipitated has been formed gradually by the action of the river itself, and not by some great convulsion during which the very crust of the earth was rent. The narrowness of the abyss, the strange zigzags along which the tumultuous waters rush after their first great plunge, the mystery which has long surrounded the further course of the river after it swings away out of sight among its forbidding precipices, and the knowledge that the rocks across which it plunges are of volcanic origin, are all factors that have aided the illusion. Hence it is not surprising to find that the explanation given by David Livingstone half a century ago, that the majestic Zambesi has here been intercepted by a rent due to some earth movement in the solid rocks, has been adopted without question in all the later descriptions of this wonderful spectacle.

Meanwhile, however, geologists have been able to prove that in other parts of the world, canyons of even more impressive dimensions than this canyon of the Zambesi have been carved out by the erosive agency of water acting through very long periods of time; and this view has very recently been convincingly advanced by Mr. A. J. C. Molyneux, F.G.S., F.R.G.S., of Bulawayo, to explain the Victoria Falls and Canyon. In Mr. Molyneux's able paper ("The Physical History of the Victoria Falls," *Geographical Journal* for January, 1905), it is shown that the prevalent idea of a sudden rent in the

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[1] A paper read before the British Association for the Advancement of Science, meeting in South Africa, at Johannesburg, August 30th, 1905. Reprinted from "The Official Guide to the Victoria Falls," compiled by F. W. Sykes, Conservator. (Bulawayo, 1905.)

earth's crust is inadequate to explain the phenomena observed aro the Falls, while all the features are compatible with the view t the river has slowly sunk its channel into the hard rocks w have barred its passage seaward; and that the great waterfall been developed as an incident in its long-continued work of eros A recent geological investigation of the country on both side the Zambesi between the Falls and the Deka River, about 70 m eastward, has yielded much evidence confirmatory of Mr. Molyne conclusions, of which we can here give only the barest outlines.

It will be remembered that the Upper Zambesi flows, with a c paratively gentle course, over a portion of the elevated platea South-Central Africa, and that when it reaches the vicinity of Falls its bed is still about 3,000 feet above sea-level. But at point it breaks sharply away from its earlier habit, to begin a r descent across the mountainous eastern margin of the continent, in doing so its capacity for erosive work is, of course, enormo increased. From the Falls onward until it reaches the coastal p about 260 miles from the sea, the river has sunk its channel de through every obstacle, carving out narrow defiles like the Lu Gorge, the Kebrabasa Gorge, the Kariba Gorge, and the can below the Falls, to which the name Batoka Gorge may be app wherever the rocks in its course are hard and resistant; excavating a wider and less precipitous valley where it crosses outcrop of strata that perish more readily.

The whole of the country for many miles on both sides of Zambesi between the mouth of the Deka and Victoria Falls, and for a considerable distance farther westward is occupied by basaltic rocks, the 'Batoka Basalts' of Molyneux, which have poured out over the land as flows of liquid lava at some re period of which the exact position in the geological time-scale not yet been definitely ascertained. Scarcely was one of t lava-flows consolidated before it was overwhelmed by another, still another, until the whole area surrounding this part of the co of the present Zambesi was covered to a depth of many hund in places perhaps many thousands, of feet of volcanic material. slowly-cooled central portions of these separate lava-flows consolidated into the dense dark-blue rocks weathering with a br crust that are so well seen in the precipices of the existing F while their more quickly cooled slaggy upper portions, once po with empty steam-cavities, have formed the deep red or pu 'amygdaloidal' bands that are rendered conspicuous to the eye, very interesting to the mineralogist, by the varied minerals depo by percolating waters. By this agency the cavities have gradually filled up with the beautiful agates, green-coated chalced quartz-crystals, and zeolites that may now be picked up so abunda at the surface along the outcrop of these amygdaloidal rocks. it may here be mentioned as of some interest to the archæol that the chalcedonic pebbles have been frequently chipped to rude cutting tools by some ancient race inhabiting the Zan valley, these relics of ancient man being especially numerous o patches of old river-gravel that are exposed around the low rocky bosses of the low ground in the vicinity of the northern bank of the river, in the angle between the Zambesi and its tributary, the Maramba.

The Batoka lavas in consolidating to their present state have developed a system of joints or shrinkage cracks which, together with rarer but more strongly marked lines of fracture or 'faulting,' have constituted planes of weakness that have materially facilitated the erosive work of the river, just as they would be found to facilitate the operations of artificial quarrying. Both 'master-joints' and 'faults' for the most part run approximately west and east, and are mainly accountable for the apparent vagaries in the course of the river, which in its innumerable windings through the Batoka Gorge tends constantly to take this direction, but crosses by rectangular or oblique traverses from one group of joints to another whenever the opportunity occurs. The Chasm into which the river plunges at the Falls is due to one of these lines of weakness in the rock, probably a fault-plane, where a vertical belt of comparatively soft vein-stuff, including a seam of crystalline calcite, breaks the continuity of the harder basalt. This vein may be examined by an adventurous climber in the little kloof at the eastern extremity of the Chasm; and its presence is indicated also at the inaccessible western extremity by the existence of a small cave, hollowed out by the surges from the Leaping Water.

At the remote period when the river first began to break across the eastern edge of the upland plains of basalt, the more powerful action of its troubled stream in this quarter, as compared with its tranquil course over the surface of the plains, must soon have brought about the development of rapids, cascades, and finally of a great waterfall separating the two portions according to their very different working capacity. The gradual recession of this waterfall by the undermining of its base and the breaking away of its edges, steadily progressing throughout the long period that these conditions have ruled in the Zambesi basin, are the main factors required for the interpretation of all the apparently complex phenomena associated with the present Victoria Falls and the Batoka Gorge; indeed, it is only thus that they become explicable. Among the many separate chains of evidence that strengthen this conclusion none is more striking than the different manner in which the tributary streams make their confluence with the main river above and below the Falls. Above the Falls the tributaries have had time to grade down their beds almost to the level of the Zambesi itself, so that (as, for example, in the Maramba confluence) we find a back-water from the main stream running for some distance into the mouth of its feeder, which here occupies a scarcely perceptible valley. Below the Falls, on the other hand, every tributary seems to emulate on a miniature scale the example of its mighty ruler and has sunk a deep gulch into the edge of the plateau roughly proportionate in length to the distance of its confluence below the Falls; and into this gulch it tumbles headlong from its older open valley on the plateau, each little waterfall illustrating in its own small way many of the characteristics so magnificently displayed by its gigantic forerunner and originator. Another equally impressive line of evidence is afforded by the gradual falling away of the angle of slope in the Batoka Gorge itself as it is followed down from its present termination at the Falls. Here, as everyone may see, its walls, carved out as it were but yesterday, are approximately perpendicular, but even here they are already beginning to crumble down under the influence of the weather; at the distance of a few miles below the Falls, where they have been longer exposed to this influence, the average inclination falls to not more than 60°, and still farther eastward to 45° or less; and finally, in the lower parts of the Gorge, instead of the familiar wall-like lines of crags, we find that the river is bounded only by rugged hillsides whose average slope from crest to base is often not more than 30°.

The processes that have operated during the immeasurable past must continue also into the immeasurable future, so long as the Zambesi continues to thunder seaward over the edge of its upland basin. Imperceptible though the rate may be when measured by the short span of our human life, yet surely is the river gnawing its path backward into the heart of the continent; and the geologist, noting how already at the rapids above the Leaping Water the trench is deepening that draws down more and more of the flood at the expense of the shallower portions of the Falls, may look forward with confidence to a future when either here or along some still lower trench at present undeveloped the main trough of the river will become fixed. The present lip of the Falls will then be left dry to form another 'Knife-edge' around which the torrent will swirl in turmoil as it passes away from its new place of descent at some line of crags at present submerged under the placid waters of the upper river.

II.—The Mount Torlesse Annelid.

By F. A. Bather, M.A., D.Sc., F.G.S., British Museum (Natural History).

AMONG the geological specimens obtained by Mr. H. T. Ferrar, while the "Discovery" was visiting New Zealand, are seven rock-fragments containing tubular shells, and an eighth with some obscure markings. They are labelled as follows:—

No. 17.	Annelid tubes?	Mt. Torlesse.	H. T. F.	Dec. 8th, 1901.
No. 18.	,,	,,	,,	,,
No. 19.	,,	,,	,,	,,
No. 20.	Scaly markings.	,,	,,	,,
No. 21.	Annelid.	Mueller Glacier.	Presd. Capt. Hutton, F.R.S.	
No. 22.	Annelid tubes?	Kowai River.	,,	
No. 23.	,,	Wilberforce River.	,,	
No. 24.	,,	Gorge of the Ashley.	,,	

Specimen No. 20 may at once be dismissed with the remark that it is merely an irregular imprint, showing no structure; even the "scaly markings" of the label appear due to incipient cleavage of the micaceous shale bearing the imprint. It may represent the "obscure plant remains" of Hector (1885, p. 339).[1]

The other specimens are all representatives of the fossil, or rather fossils, long known to the geologists of New Zealand as "the Mount Torlesse Annelid." This fossil is so abundant in certain dark-coloured slates and sandy shales, as to have procured for them and their associated sandstones the name of "the Mount Torlesse Annelid Beds" or "the Annelid Beds." These beds are usually regarded as the uppermost division of the Maitai Series, since they appear to be conformable with the underlying limestones, slates, and sandstones of that series. The fossils found in the Maitai Limestone, the basement bed of the series, as quoted by Mr. A. M'Kay (1879 and 1881) and by Captain F. W. Hutton (1885) are obviously Carboniferous, and, if correctly identified, should be regarded as Lower Carboniferous. Unfortunately the country in which the undoubted Annelid Beds occur is much disturbed, so that the stratigraphical evidence as to their relations is not free from uncertainty, and other beds have, it is now known, been confused with them in several cases (see, for example, Von Haast, 1885). Unfortunately also, the supposed Annelids are the sole fossils found in the beds. Thus the opinion published by Mr. M'Kay in 1881 still expresses the truth, namely, that "the placing of these Annelid beds in their correct position is unquestionably the most difficult problem that has yet to be dealt with in perfecting the classification of the older sedimentary rocks of New Zealand." "Much therefore," he continues, "depends upon the presence, absence, or correct identification of the annelid, which importance it must retain until other and more determinate forms are discovered" (op. cit., p. 90). Mr. M'Kay consequently proceeded to give a brief description, but up till now no figure has been published, and no comparison has been made with other fossils.

The material, as recognised by Mr. M'Kay, contains two quite distinct forms, which, however, are said to be found in precisely the same strata. One of these is straight (Nos. 17, 18, 19, 21, 24), the other curved (Nos. 22, 23). The former is the most widely distributed, being especially abundant and well preserved at Ashley Gorge, whence comes our specimen No. 24. The latter, according to M'Kay (1881, p. 91), is found only on the west coast of the South Island. The Kowai River, however, whence comes our No. 22, is on the east coast, disembogueing a little north of Port Lyttelton. With this exception, the localities quoted by Von Haast (1872 A–B), M'Kay (1881), Hector (1885 and 1892) may be supposed to refer to the straight form. It is pointed out by M'Kay that, although this fossil is called the annelid of Mount Torlesse, and although a long list of localities for it has been published, "it is nowhere spoken of as actually having been collected from Mount Torlesse." Hector, however (1885, p. 339), quotes it from "the south-eastern end of Mount Torlesse," while Mr. Ferrar found it to be "quite abundant near the summit of the hill."

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[1] See end for List of Papers referred to.

THE STRAIGHT FORM. (FIGS. 1–3.)

Mr. M'Kay (1881, p. 90) described this as "a tapering tubular calcareous[1] body, varying from one to three inches in length, the greater diameter of the larger specimens being not more than a quarter of an inch. In most cases when they occur between the bedding planes of the rock they are found flattened by the pressure of the overlying stratum, but when found vertical or highly inclined to the bedding planes they preserve their cylindrical form. In their fossil condition the walls of the tube are sufficiently thick to have resisted any ordinary amount of pressure exercised by the overlying beds, and therefore it may be doubted if they have always been as calcareous as they now are." Mr. M'Kay believes that the animals "were during life fixed to one place," and that the vertical "is their natural position."

To the preceding little can be added beyond more precise measurements. The greatest length of any of our specimens (No. 24, Fig. 1*a*) is 71 mm. (a little less than 3 inches), but this is obviously incomplete, being truncated at the smaller end by a slickensided joint-face, while the larger end has been broken off. At the smaller end, which is much flattened, the mean diameter is $(2\cdot3 + 1\cdot4) \div 2 = 1\cdot85$ mm. ($= \frac{1}{14}$ in.). At the larger end the mean diameter is $(2\cdot9 + 1\cdot9) \div 2 = 2\cdot4$ mm. The rate of tapering, therefore, is very slight, and the same is the case in other specimens. Since all the specimens are flattened in the plane of bedding, the lumen appears as little more than a dark line. A section of another individual in No. 24 gives the following measurements:—Greatest diameter, 4·7 mm. Least diameter, 1·3 mm. Greatest width of the compressed lumen, 2·7 mm. Thickness of tube-wall, on one side of lumen, ·3 mm.; on the opposite side, ·8 mm.; at one end, 1·3 mm. Probably this last measurement is exaggerated, and the lumen was really longer in this direction. Before compression, therefore, the tube at this level may have had a diameter of about 3·5 mm. with a wall ·8 mm. thick, and a lumen 2·7 wide, or just under four-fifths of the total diameter. These measurements should be checked from individuals preserved in a vertical position, such as unfortunately do not occur in the material under examination; but assuming their approximate correctness, it can scarcely be maintained that such a tube with its infilling of fine mud ought, however "calcareous," to have resisted the considerable pressure to which it has been submitted—a pressure which the rock-specimens themselves, as well as the published sections of the country, show to have been by no means "ordinary pressure exercised by the overlying beds." Consequently, there is no reason to suppose that the tube-wall was ever more horny than calcareous. As a matter of fact Mr. M'Kay's argument starts from an erroneous assumption: the substance of the fossil is not a carbonate or any salt of lime, but a chalcedonic form of silica. In section the fossils are generally somewhat hour-glass or dumb-bell shaped, but this is an ordinary effect of compression, and there is no trace of lateral ridges such as characterise *Serpulites*. Unequal compression and a slight tendency to cleavage in the rock have produced inequalities of thickness, but the general impression produced is that the tubes were remarkably straight and not curved as in *Serpula*. The surface appears to have been smooth, but, if anything, irregularly and finely striate longitudinally rather than polished (Fig. 1*c*). There are no transverse annulations, wrinkles, or striæ, but specimen 19 shows a slight transverse swelling at one level (Fig. 2). The evidence at hand does not show whether the tube was closed or open at the smaller end. Probably it was not operculate at the broader end, or traces of the opercula would have been found.

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[1] Hector (1886, p. 339) also says "a calcareous tubular body." None of the specimens submitted by Mr. Ferrar are calcareous, but all, from all localities, are silicified throughout.

Owing, perhaps, to its silicification, no microscopic structure can be detected in a thin transverse section of the tube (Fig. 3).

The specimens of rock, of which an average sample measures 100 × 62 × 18 mm., contain as a rule traces of more than one individual, but they are not very closely associated. Since there are in the rock no other solid bodies to which they can have been attached, it must be inferred that the tubes were free and isolated. While the evidence of the vertical specimens suggests that they were sedentary and embedded in the mud, the still greater number of specimens in the plane of bedding leads one to enquire how and when they left their vertical station.

The systematic position of this fossil is far from clear. There seems, indeed, no reason to doubt the unanimous ascription of it to the Polychæta tubicola, at least with as much reason as *Serpulites*, *Cornulites*, and similar forms; but the genus is not so obvious. Captain Hutton (1885) has suggested that certain annelids from the Upper Maitai beds of the Dun Mountain[1] are "perhaps *Cornulites*." The present specimens, however, assuming that they are of the same species, do not support that view, since they are devoid of annulations and taper much less rapidly.

From *Serpulites*, as defined by Mr. R. Etheridge, fil. (1880, p. 304), this species differs in the absence of the lateral ridges and in its straightness. The genus *Serpula*, as defined by Linnæus (Syst. Nat., 1758, p. 786), had "Testa univalvis, tubulosa, adhærens, sæpe isthmis integris passim intercepta." It is true that the first species mentioned by him, *Serpula seminulum*, "recedit a congeneribus quod libera sit nec adhæreat aliis corporibus," but this species cannot be taken as the genotype, and it seems justifiable to follow R. Etheridge, fil. (1880, p. 362) in regarding adherence as a necessary criterion of the genus. Another feature almost universally ascribed to *Serpula* is the irregular contortion or enrolment of the tube. On both these counts the Mt. Torlesse annelid is not a *Serpula*.

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[1] Accounts of the Maitai beds of the Maitai River and Dun Mountain district near Nelson have been given by M'Kay (1878 and 1879), who, however, mentions only "Annelid tracks" and a shell like *Inoceramus*. But these beds were not then correlated with the Annelid slates and sandstones of Westland and Mount Torlesse, which were placed in an underlying Rimutaka series (see Hector, 1878).

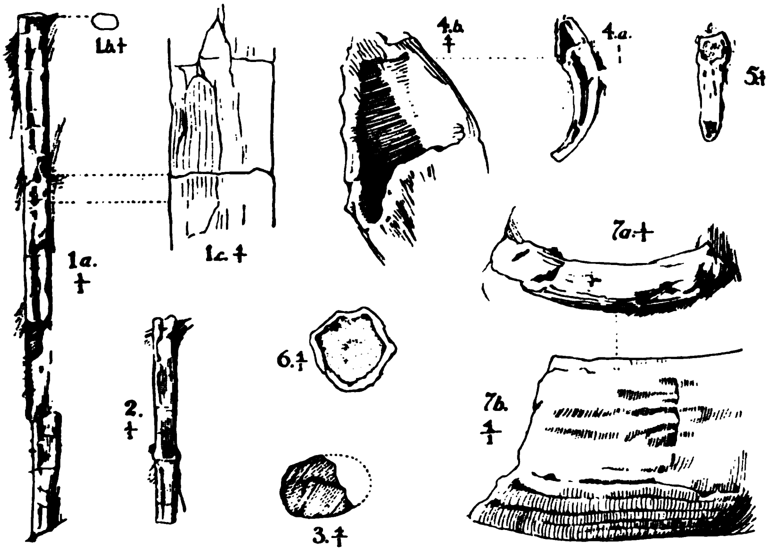
The annelids secreting firm calcareous tubes do not, however, appear to furnish any other genus with which comparison would be profitable, and in general appearance this fossil most nearly resembles certain fossils rightly or wrongly assigned to *Serpula.* It is not the Mesozoic or Cainozoic species that it in any way resembles, but certain Palæozoic species, and of all these the resemblance appears closest to the Carboniferous fossil named *Dentalium indistinctum* by Fleming (1825) and *Serpula compressa* by J. de C. Sowerby (1829). That species, however, which certainly agrees with *Serpula* in its irregular curvature, and probably in its partial attachment, further differs from the Mount Torlesse fossil in the more rapid tapering and its relative tenuity of its tube-wall, notwithstanding the fact that the wall is described as "thick." It is thick relatively to the Palæozoic serpuloids, which therefore need not further be brought into comparison.

It is probable, and has thus far been assumed, that the tube of this fossil, though now chalcedony, was originally a firm calcareous secretion, a view confirmed by the composition of the other Mount Torlesse fossil. There is, however, just the possibility that the tube was an aggregate of sand-grains as in *Terebella.* The tubes of the various species of that genus differ from the present fossil in their irregular growth, while the calcareous sand-grains of which they are composed are certainly coarser than any which could possibly have entered into the composition of the New Zealand fossil. A much closer resemblance is presented by tubes from the Yakutat Slates of Alaska, recently described by Mr. E. O. Ulrich (1904, p. 132) as *Terebellina Palachei,* gen. et sp. nov.; indeed, some of his figures (pl. xi, figs. 2, 5) might almost serve as illustrations of our specimens. *Terebellina* is thus diagnosed:—"Long, subcylindrical, gently curved and rather thick-walled tubes, acuminate below; surface obscurely striated transversely. Tubes composed of cemented minute siliceous grains." These grains are "essentially the same as those of the arenaceous shale in which" the fossils "are found," but are "of more uniform and larger average size in the tubes than in the matrix." The length, the very gradual tapering, and the thickness of the wall ("about two-thirds of the diameter is taken up by the central hollow") are all points of resemblance to our fossil. It is further noteworthy that in Alaska as in New Zealand these peculiar worm-tubes serve to correlate exposures of slate of undetermined age in widely separated localities, and that the only other fossils are supposed fucoids and, in one locality, a peculiar concentrically ribbed Inoceramus-like shell. The Alaskan shell is named *Inoceramya* by Mr. Ulrich, to express his opinion that it is intermediate between *Posidonomya* and *Inoceramus.* On the evidence of all these fossils Mr. Ulrich assigns the Yakutat Slates to a Liassic age. But, although it would be important as well as curiously interesting to identify the Mt. Torlesse annelid with *Terebellina,* this course does not appear possible. Apart from the absence of any structure suggesting a similar constitution of the tube-wall, there are differences in the absence of curvature and in the signs of a longitudinal rather than a transverse striation.

We come then to the conclusion—particularly unfortunate for the stratigrapher—that the straight annelid of Mt. Torlesse cannot be ranged with any established genus. Although further information is desirable, still it may be well to draw attention to the fossil by giving it a name:—

Torlessia, gen. nov.

A tubicolous Polychæt, of which the tube is unattached, straight, very slightly tapering, circular or elliptical in section, and with relatively stout, unridged, (originally) calcareous walls (*circa* one-tenth diameter); habitat, vertical in marine mud.



TORLESSIA MACKAYI and DENTALIUM HUTTONI.

1. *Torlessia Mackayi*, No. 24. *a*, natural size; *b*, section; *c*, portion of surface, to show striæ, × 4 diam.
2. *T. Mackayi*, No. 19. Natural size.
3. *T. Mackayi*, No. 19. Transverse section from another individual, × 4 diam.
4. *Dentalium Huttoni*, No. 22. *a*, a shell lying on its side, nat. size; *b*, larger aperture of same, showing ridges, × 4 diam.
5. *D. Huttoni*, No. 22. Another shell lying with the smaller curve uppermost, nat. size.
6. *D. Huttoni*, No. 22. Section of another shell as seen on the surface of the stone, probably not quite transverse, and partly crushed, × 4 diam.
7. *D. Huttoni*, No. 23. *a*, the largest individual on the stone, nat. size; *b*, a portion showing the ridges, × 4 diam.

Genotype, *Torlessia Mackayi*, n.sp.

Surface smooth or with faint longitudinal striation; description as above.

The association of Mr. Alexander M'Kay's name with this species requires no justification, as this is one of the rare cases in which the adoption of a personal name conveys a meaning which is not misleading.

Holotype: Specimen No. 24 of Mr. Ferrar's list (Fig. 1). Nos. 17, 18, 19, and 21 also belong to this species.

Horizon: Probably not below Upper Carboniferous and not above Trias (see Von Haast, 1887).

Localities: Ashley Gorge (holotype), Mueller Glacier, Mt. Torlesse, and many other places in New Zealand, especially Hutt and Selwyn counties (see Hector, 1885 and 1892).

THE CURVED FORM. (Figs. 4–7.)

This has not hitherto been described. It is represented by specimens 22 and 23, both collected by Captain Hutton. No. 22, from the Kowai River, is a water-worn pebble from which one quarter has been broken away. The substance of the pebble is a very hard dark-grey shale, weathered greenish. It is 19 mm. thick, 80 mm. long, and 63 mm. wide. On one of the flat surfaces, occupying an area about 52 mm. long × 50 mm. wide, are the remains of nineteen individuals, of which the most complete measures 19·3 mm. along the chord of the curve (Fig. 4). No. 23, from the Wilberforce River, is a fragment of hard black shale, iron-stained, slightly contorted, slickensided at one end, and with numerous cracks filled with silica. It is 14 mm. thick, 96 mm. long, and about 40 mm. wide. One flat surface is slightly water-worn and displays the remains of three individuals, of which the most complete measures 28·5 mm. along the chord of the curve (Fig. 7). In both specimens the substance of the fossils is silicified.

The above numbers suggest that these animals were more gregarious than *Torlessia Mackayi.*

In No. 22 the shells lie in all positions: most are in the plane of bedding, either on their sides, or with the concave curve up, or with it down; a few, of which only a transverse section is seen, appear to lie at an angle to the plane of bedding. Those which lie in the bedding-plane are compressed, and the side that happens to lie uppermost is usually pressed inwards so as to make the transverse section approach a semicircle or even a crescent. That this is an effect of pressure is further shown by the fact that the transverse sections mentioned above are more circular in outline.

The individual, 19·3 mm. long, on specimen 22, lies on its side, having the uppermost side crushed in, as above described, over the middle of its course, but partly broken away at the ends. The larger, convex curve has a radius of 12 mm. (a trifle over that of a shilling). The smaller, concave curve has a radius of about 7·6 mm., but is not so nearly a segment of a true circle. The outside diameter of the tube at a little distance from the larger end is about 4·3 mm., but since this end is broken, the diameter at the wider aperture cannot have been less than 5·3 mm., from which perhaps a little should be deducted for the flattening. At the smaller end the outside diameter is 1·6 mm. The thickness of the tube-wall at the larger end is not less than ·3 mm.; at the smaller end it was rather thinner. It is doubtful whether the transverse section was circular; it may have been slightly polygonal. The inner wall of the tube is smooth, but the outer wall was covered with about fourteen slight but distinct longitudinal ribs (Fig. 4*b*). These are almost or entirely worn away from the exposed surfaces, but are seen in section, and often on the impressed portions of the outer wall.

The three fragments preserved in specimen 23 all appear to have belonged to individuals rather larger than those in No. 22. They are much worn, and the tubes appear to have been filled with a greenish chalcedony rather than with shale. The ribs are shown in each of them, and very plainly in the largest, where three of them occupy a width of 1·2 mm. (Fig. 7*b*).

Of this form also, the systematic position is not free from doubt. Hitherto it has generally been regarded as the tube of an annelid, but to this there are certain objections. The shell, for instance, seems rather too stout and too regularly curved. Its general shape reminds one of *Cornulites*, to which Captain Hutton referred some tubular fossil (loc. cit. supra), but it is ribbed, not annulate. If an annelid it would be suggestive of a far later age than that to which stratigraphical evidence would assign it. Short, curved annelid tubes with longitudinal ribs do not seem to occur before the Lias, in which epoch there lived "*Serpula*" *quinquecristata*, Goldf., "*S.*" *tetragona*, J. de C. Sow., and *S. quadrilatera*. *Serpula heptagona*, Sow., from the Barton Beds of the Upper Eocene, is a similar form. But the most suggestive are the tubes from the Maestrichtian Chalk, now referred to Denis de Montfort's rather problematical genus *Pyrgopolon* (1808), e.g. *P. deforme* (Lam.) and *P. ciplyana*, Ryckholt. But none of these real or supposed annelid tubes has the same regularity of shape as appears to have been possessed by the present fossil. And if not an annelid, the conclusion is inevitable that it is the shell of a Scaphopod, probably of the genus *Dentalium* (sens. lat.). Since that genus, or some close ally thereof, has persisted from Devonian times to the present, this conclusion, while throwing no fresh light on the age of the rocks, is at least in harmony with other evidence. Several species of *Dentalium* or its subgenus *Entalis* have been recorded from Carboniferous rocks. Since the habitat of *Dentalium* is in marine mud, this conclusion further agrees with the evidence afforded by *Torlessia*. The fact that the stereom has been converted into silica renders inapplicable the argument from its arragonite or calcite constitution, and also prevents the investigation of its microscopic structure.

The tubes show no trace of slits at either end, so that it is legitimate to leave them in the genus *Dentalium*, even as now restricted (see Simroth, 1895, p. 458). Among the species of *Dentalium* (sens. lat.), both recent and fossil, the one to which the present form seems to bear most resemblance is *D. formosum*, Adams and Reeve, from the China seas, since that tapers rather rapidly and has longitudinal ribs of about the same degree of coarseness. That species, however, has an apical fissure, is much straighter, and marked with transverse lines of growth. None of the Carboniferous species are so coarsely marked as the present one. It seems necessary, therefore, to establish:—

Dentalium Huttoni, n.sp.

A *Dentalium* (or allied genus) of which the shell tapers rapidly (from 25 to 7·5, length being taken as 100) and is strongly curved (radius of outer curve being *circa* 12 mm.), with about fourteen distinct longitudinal ribs.

Here too the name of the collector and donor of the specimens described, the lamented New Zealand geologist who himself alluded to them in his published writings, seems highly appropriate for the trivial appellation.[1]

Holotype: Specimen No. 22 of Mr. Ferrar's list (Fig. 5).

Horizon: Said to be the same as that of *Torlessia Mackayi*.

Localities: Kowai River (holotype), Wilberforce River (No. 23), and west coast of the South Island (*fide* M'Kay), all in New Zealand. Perhaps this is the same species as was found in the Maitai Series of the Taipo ranges by S. H. Cox (1877, p. 78) and referred by him to *Dentalium*; but it is not, of course, the same as any of the *Dentalium* from much later rocks recorded by M'Kay (1877, pp. 101, 110, 116, 117).

I am indebted to my colleagues Mr. Edgar Smith and Mr. G. C. Crick for kindly looking at these obscure fossils, and for raising no objection to the systematic position here proposed for them.

PAPERS SPECIALLY REFERRED TO.

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[1] See p. 575.

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III.—ON THE PROBABLE PELEAN ORIGIN OF THE FELSITIC SLATES OF SNOWDON, AND THEIR METAMORPHISM.

By J. R. DAKYNS, M.A., and EDWARD GREENLY, F.G.S.

PART I: By J. R. DAKYNS, M.A.

THERE are several kinds of acid volcanic rocks in Wales. In the neighbourhood of Snowdon there are at least five kinds, as follows:—

1. There are undoubted lavas, showing lines of viscous flow and sometimes vesicular, and weathering into cubical blocks. Such may be seen on Crib Goch and on Crib Yddysgl, on Cerrig Cochion, and elsewhere. These rocks are rarely cleaved.

2. There are rocks like the last as to fracture and mode of weathering, but which are neither viscous nor vesicular. They are probably masses of felsitic dust or mud. Such may be seen in Cwm Llan.

3. There are also massive felstones, rudely cleaved, such as form Moel Meirch and Clogwyn Llwyd.

4. There are the so-called ashes of various kinds, usually well-bedded and often highly cleaved.

5. Lastly, there are highly cleaved felsitic rocks, which show no lines of viscous flow, are generally unbedded, and which are in many places fragmentary. They are markedly different from the undoubted uncleaved lavas with which they are in some places associated; and though not readily to be distinguished from cleaved lavas they are so often obviously fragmentary that I cannot but consider them to be mainly of clastic origin.

With reference to these rocks Mr. Greenly wrote to me immediately after the meeting of the British Association at Southport in 1903, saying that he thought the volcanic eruptions in the West Indies threw some light on their origin. Hence this paper, in which he sets forth his views on the subject. He proposed that we should write a joint paper, but I did not see my way to doing this, as I had no definite area mapped, and had not separated the cleaved felsitic rocks of doubtful character from the undoubted lavas and ashes.

I ought to say that the rocks like felsites in which I found fossils in 1900 occur in the calcareous felspathic ashy series near the base thereof; but are coloured pink on the Geological Survey map as part of the lower Snowdonian felstones. I have since then found fossils in another locality in an area so coloured, but not in a rock looking like a felsite. The fossils which I found in such a rock in 1900 were kindly named for me by Mr. E. T. Newton. They were *Strophomena* and *Orthis*; but the specimens were too poor for specific determination. The day after finding these fossils I discovered a small area of slaty rocks containing fossils, from 1,000 to 1,300 yards west of the summit of Moel Meirch, and entirely surrounded by the felstone of which that hill is composed. The relation of the fossiliferous rocks to the felstone is not clear. I suppose it to be an outlier, possibly faulted, of the calcareous ashes which, according to the Geological Survey map, overlie the felspar of Moel Meirch.

Though I have not finished mapping any well-defined area occupied by the cleaved felsitic rocks which form part of the lower Snowdonian felsites, I may point out some of the places where they occur and also places where they are of a fragmentary character. Cleaved felsites occur in Cwm Llan, extending from Lliwedd past Geuallt and along the lower slopes east of Graig Wen. Their fragmentary character is well seen in Cwm Llan near the Gladstone monument. How like these rocks are in some places to the overlying ashes is shown by the fact, mentioned in the Geological Survey Memoir on North Wales (p. 151 of the second edition), that Mr. Selwyn had great difficulty in drawing a line of demarcation between them on the side of Cwm-y-llan near Yr Aran. It seems to me that the chief distinction in many places between the two sets of rock is that one is generally bedded and the other not. Though I have failed to find anything like stripe or lamination due to bedding among the cleaved felsites of Geuallt, yet I have noticed a set of features, roughly parallel to the bedding of the ashes, running across the southern face of the hill. These are very conspicuous in a good light, and are suggestive of bedding; but they may be due to jointing. Cleaved felsites also extend from Bryn Gwynant, past Llyn Dû and Hafod Owen. Their fragmentary character is well marked in Coed Eryr and Coed yr Odyn. After crossing the line of the north-westerly fault at Perthlwyd, the rock forming the mountain between Llyn y Ddinas and Nant y Mor is felstone of the compact type, like that of Crib Goch, and is in places spherulitic. Cleaved felsites also occur in the outlier of felstone above Gelli Iago. The greater part of this outlier is compact uncleaved felstone with lines of viscous flow; but a small portion of it is a cleaved rock of a quite different character, and in connection with this there is some bedded rock. I have not yet made out the relation of these two kinds of felsite to one another. There are probably some undetected faults, for, to mention only one place where such may occur, at the north-east end of the outlier shown on the map the underlying grits are dipping eastward so as to pass *over* the felstone or abut against it. The junction of the felstone here with the sedimentary rocks is more like the junction of an intrusive rock; but possibly this appearance may be due to faulting. There are other difficulties about this small outlier and also with the base of the felstone near Hafodydd-brithion, which I pass over, as they have nothing to do with the cleaved felsites which are the subject of Mr. Greenly's paper.

PART II: By EDWARD GREENLY.[1]

Introduction.

Every geologist who has visited Snowdon must have observed that very large masses of highly cleaved, yet felsitic, rocks enter into the structure of the mountain, in addition to the unmistakable felsitic lavas and bedded calcareous ashes.

These rocks, which for conciseness may be called the 'Felsitic Slates,' are conspicuous along most of the ordinary approaches, except from Llanberis. The path from Pen-y-gwryd passes across them, and so does that from Beddgelert: they form the sharp ridge of Llechog, south of Cwm Clogwyn, and the great dark precipices of Lliwedd overlooking Llyn Llydaw are largely composed of them.

They are dense, hard, splintery rocks; intensely cleaved, and yet with the light weathering of a felsite, and also on fresh fractures their pale bluish-green matrix has, in spite of the strong cleavage, a decidedly felsitic aspect, while their cleavage laminæ are perceptibly translucent at the edges. Small squarish crystals of felspar, from 1·0 to 1·5 mm. long, are generally present and often abundant.

Most writers on Snowdon have, discreetly perhaps, said very little about them, for they are very unpromising-looking rocks. Sir A. C. Ramsay and Mr. Selwyn, however, having to survey the country, were obliged to deal with them in some way, and they have included them on the maps with the lower or principal felsitic lavas, with which they are coloured and lettered 'F.' Moreover, in the memoir (Geol. North Wales, 2nd ed., pp. 150–1) the intense cleavage is thus referred to: "On the ridge of Llechog, west of the peak of Snowdon, the felspathic porphyry is curiously cleaved, or at least very closely jointed; and so marked is this above Cwm-y-Clogwyn that it is difficult at first to believe that it is part of the very same slaggy-looking masses previously described. So completely is the appearance of the felstone of Llechog, and of the cliff below the peak of Snowdon, modified by this structure, that there is the utmost difficulty in fixing on a boundary-line between it and the overlying ash, both being felspathic and both cleaved and jointed. It is difficult to recognise the probability of intense cleavage being induced in a rock that has been melted, accustomed as we are to consider that cleavage of this nature is confined to stratified rocks. Less than two miles from this spot, on the sides of Cwm-y-llan, near Yr Aran, the same structure is remarkable, and it was not till after repeated visits and much study on the spot that Mr. Selwyn was enabled to draw the lines of demarcation between the ashes and the felspathic porphyry."

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[1] All the field-work upon which this paper is founded is by Mr. Dakyns. I have only visited the ground a few times.—E. G.

Mr. Harker, in describing the rhyolitic lavas, refers merely to an 'incipient' or 'imperfect' cleavage,[1] distinguishing it from the fine platy jointing and fluidal structure; and it is evident, therefore, that he is not referring to these rocks, in which the cleavage is correctly described by Ramsay as 'intense.'

Evidence of Clastic Origin.

In this Magazine for June, 1900, p. 268, in a paper on "First-fruits of a Geological Examination of Snowdon," Mr. Dakyns described these felsitic slates, distinguishing them from the other components of the lower felstones. He pointed out that in many places they can be seen to be fragmental (giving localities), and that these obviously fragmental rocks are part and parcel of the fine felsitic slates. He also drew attention to the absence of bedding, a character which we shall consider further on. We may add, perhaps, that were these rocks felsitic lavas, abundant traces should be found of the fluidal and also of the spheroidal structures that are so frequent in the true lavas. Cleavage would not have obliterated these throughout so large a mass of rock. In the paper quoted some microscopical evidence was also adduced, the most important part of which was that the felsitic slates contain a considerable quantity of calcite, whereas the felsitic lavas have in no case[2] yielded more than ·34 per cent. of lime.[3]

Re-examination of the same material has shown that some of the "small aggregates with igneous structure" are really felspars which have undergone a peculiar kind of alteration. But to this we shall revert in describing the metamorphism. Besides these, however, there are oval bodies consisting of felspars bound together by iron oxide and indeterminate brown matter, which probably represents a more basic glass, and these appear to be genuine lapilli. The fine matrix is far too much deformed and indeed reconstructed to retain any trace of its original texture, except under the sheltered 'lee' of some of the larger felspars, and in these parts smaller, subangular felspars can be seen which have the aspect of broken grains.

The conclusion arrived at by Mr. Dakyns in his paper of June, 1900, was that the rock was a felsite tuff or dust.

[1] "Bala Volcanic Series," pp. 16, 17.

[2] Harker, "Bala Volcanic Series," p. 13.

[3] The average of eight analyses of ancient and modern rhyolites given in Sir A. Geikie's "Text Book of Geology," 4th ed., 1903, p. 212, is ·698.

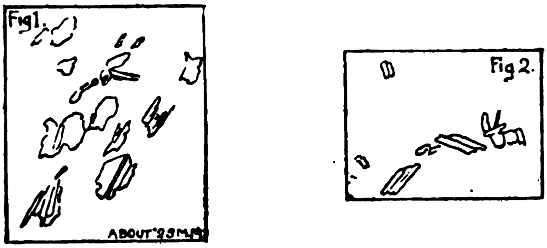
Fresh Evidence.

In April, 1900, Mr. Dakyns, while seeking for a good line of division between the calcareous ashy series and the underlying felsitic rocks at Hafod Llwyfog, near Llyn Gwynant, found, in a band of felsitic slaty rock, some Brachiopoda, the best preserved of which were *Strophomena* and *Orthis*, though Mr. E. T. Newton, F.R.S., who kindly examined these fossils, hesitated to name the species. Of the clastic origin of this rock there could therefore be no doubt.

To the unaided eye, or with a pocket lens, it has the same aspect as the other felsitic slates, though somewhat less fissile. If anything, it looks rather more like the felsitic lavas than they do.

Under the microscope, it is seen to be somewhat less altered, and the original character of even the finer parts can still be made out in places. It consists of the same small felspar crystals, set in a fine grey matrix, with streaks of calcite dust, which would account for the calcite before noted in the more altered varieties. There is also some chlorite. This matrix can be seen to be undoubtedly clastic, and consists of very small grains of felspar (quartz has not been identified), often of very irregular form. In other parts of the slide nothing but aggregate polarisation can be seen.

The most singular feature, perhaps, of the rock is the presence of a number of small flakes of biotite, with strong pleochroism, rich brown to nearly colourless. These are sometimes isolated, but more often in groups (Figs. 1 and 2), in which they and small felspars are bound together by matter partly felsitic (giving aggregate polarisation) and partly still isotropic. The biotite flakes lie in all directions, and are evidently original constituents. Their arrangement suggests that these groups were originally lapilli, in which the biotites and felspars were cemented by a certain amount of glass. Most of the chlorite of the rock can be seen to be due to the alteration of biotite. Biotite in an unchanged condition has not, so far as we remember, been described from the Felsitic Series of Snowdon.



FIGS. 1 and 2.—Groups of Biotite Crystals in Fossiliferous Felsitic Rock. Highly magnified (about ·23 mm.).

This rock, therefore, is a dust, mainly felspathic, but containing scattered lapilli of a somewhat more basic character.

Cleavage and Metamorphism.

Allusion has been made above, and was also in Mr. Dakyns' paper of 1900, to the alteration which these rocks have undergone in connection with the production of their cleavage; and in order to convey a clear idea of what they are now like it will be well to describe this, especially as some of the phenomena are in themselves of general interest.

The body of the rock is now an exceedingly fine mosaic, giving aggregate polarisation, but throughout this is a wonderful development of white mica, fine indeed, but with some flakes quite large enough to be recognised as individuals, and to give tints as high as the first blue in a slide in which the felspars give nothing but low greys. No part is free from this mica, but it is also aggregated into anastomosing seams, of which some are as much as ·5 mm. thick and wholly composed of mica. Indeed, between crossed nicols the whole slide lights up with its brilliant polarisation colours. There are many rocks in regions of admitted crystalline schists in which the development of mica is nothing like as great.

There is also a good deal of chlorite and some grains of quartz, and there are many lenticles of calcite, some of which reach 3 mm. in length by ·5 mm. in thickness.

Most conspicuous are the crystals of felspar, many of which have well-defined outlines, and often re-entering angles. Round these sweep the micas of the matrix, leaving the spaces under their 'lee' to which reference has been made.

The micas, however, do not bend completely round them, for in many cases they penetrate the crystal for some distance, its original outline being then obliterated. This generally happens at the ends of the augen, the micas which lie within the felspar crystal having the same direction as those of the matrix, the direction, that is, of the slaty cleavage. This is the same phenomenon as was described some years ago by one of us from the Harlech Grits.[1] In that case the cause could not be indicated with certainty. Here it is evidently an incident of the production of the cleavage.

In the microscopical notes incorporated in Mr. Dakyns' paper of 1900, mention was made of certain bodies with igneous structure, believed then to be fragments of igneous rocks. Most of them are lenticular augen composed of intergrowths of felspars, with beautiful polysynthetic twinning (Fig. 3). They lie in all directions within the lenticle, and interlock at their edges. In some cases chlorite and other products are also present, and it is possible that some of these bodies may really be lapilli. But re-examination has shown that a number of bodies, often with rectangular outlines, their longer axes lying sometimes transverse to the cleavage, and quite indistinguishable in ordinary light from the larger original felspars of the rock, reveal between crossed nicols the same internal structure as these complex felspar augen, being composed of a mosaic of clear, well-twinned felspars (Fig. 4). Some of the largest original felspars also show a tendency to break up at their edges into a mosaic. It is evident that the rectangularly bounded aggregates are really reconstructed felspars, and it is therefore probable that the lenticular aggregates are also felspars which have been deformed externally as well.

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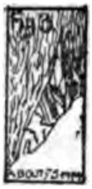
[1] Greenly, Trans. Edinburgh Geol. Soc., vol. vii (1897), p. 251.



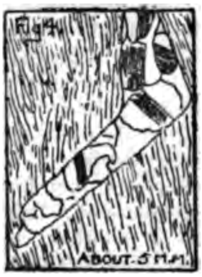


Fig. 3.—Felspar Lenticle in Felsitic Slate. About ·75 mm.
Fig. 4.—Reconstructed Felspar in Felsitic Slate. About ·5 mm.
In both figures the shaded bands are twin lamellæ.

This reconstruction of felspar is most interesting, particularly as it is evidently here a result of dynamic metamorphism, and as the resulting product shows no trace of mechanical crush or strain. Indeed, the extent to which mineral reconstruction has been carried is remarkable, when we reflect that no one would have called any rock of the series a 'crystalline schist'; that the results can be ascribed to no other agency than that which has impressed the slaty cleavage; and that this agency did not come into operation until after the Ordovician period.

Exceptional Nature and probable Origin of the Rocks.

From the evidence given in this paper it is clear that volcanic dust forms a large part, even if it does not form the whole, of the felsitic slates of Snowdon.

But the most remarkable feature of the deposit is the exceeding rarity of any signs of bedding. Intense though the cleavage is, it could not have obliterated this, nor indeed has it done so in the ashy series above or the sedimentary series below. And ages of weathering on the exposed faces of lofty cliffs could hardly have failed to reveal bedding if any existed; but in Llechog and other great crags nothing can be seen from top to bottom but the uniform vertical divisional planes which determine every feature. Yet such a mass of dust, if projected in the ordinary manner, and falling as a rain of ashes, could not fail to become stratified, even in the open air, much less on a sea bottom. The overlying ashy series is well stratified, and yet it is composed of much coarser material. Evidently, therefore, the felsitic slates, if a dust, must be due to some unusual kind of eruption.

Now, those who have read the fascinating report of Drs. Anderson and Flett on the West Indian Eruptions of 1902, will remember that absence of stratification is stated to be a marked characteristic of the deposits of St. Vincent, and is ascribed by them to the sudden and torrential or avalanche-like manner in which they were poured out.[1]

It is true that the phenomena which have given such a dramatic interest to these eruptions—the furious rush, the deadly blast, and the great black cloud—are essentially subaerial, and that the volcanic series of Snowdon is generally regarded as submarine. But as the conditions for the type of eruption, called by the authors of the report the Pelean, are determined in the throat of the volcano before emergence, there is nothing to prevent such eruptions taking place from submarine vents.

The felsitic slates, therefore, present in a striking manner one of the leading features of a Pelean deposit.

But there is another characteristic of a Pelean dust, equally important, and that is the high proportion of crystalline to glassy grains.

An ancient Pelean deposit ought, therefore, to be a largely crystalline deposit, and if not too much altered ought to retain some traces of this. The rocks under discussion, as we have shown, are for the most part much too highly altered for any but their larger original grains to be recognisable, but these grains are crystalline, and so far agree.

The fine matrix, in the highly altered rocks, might have been originally either crystalline or glassy, and proves nothing either way. But the fossiliferous specimen, we have seen, is much less altered; to it, therefore, we may appeal. Parts of it now yield aggregate polarisation, and these may, and very likely do, represent particles originally glassy, now devitrified, and there is even a little isotropic matter still surviving. But the greater part consists of broken felspars set in a dusty matrix in which smaller and smaller clastic, crystalline, particles can be detected, until we reach the limit of vision.

The dust is a crystalline dust, and, in addition to this, the groups of biotite crystals, cemented by what appears to have been glass, recall the lapilli with microliths and the crystals with glass adhering to them of the typical Pelean products of 1902.

Such evidence as we have, therefore, goes to confirm the view, suggested in the first instance by their behaviour in the field, that in the felsitic slates of Snowdon we have a Pelean deposit of the Ordovician period.

Concluding Considerations.

One or two points call for remark. The particles, except the larger felspars, are decidedly smaller than those of the West Indian dust-clouds, even than what was collected at Barbadoes, some ninety miles away from the volcano. Possibly an acid magma may dissipate itself into finer débris than an intermediate one.

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[1] Phil. Trans. R.S., 1903: Report on the Eruptions of the Soufriere, etc., pp. 448, 470.

Then another point—and we confess to feeling somewhat staggered by this—is the enormous size of the mass. In the cliffs of Lliwedd alone several hundred feet of the deposit can be seen, and this may not be all, even if the rest of the horizon, estimated by Ramsay at 1,700 feet in all, be largely composed of lavas.

Another circumstance shows a curious coincidence. Drs. Anderson and Flett remark (Report, pp. 400, 505) that the Pelean type of eruption appears to be generally followed, when once the great black cloud has rolled away, by a 'rain of ashes' of the ordinary kind. Now in Snowdon itself it is certainly the case that the felsitic slates are succeeded by the bedded ashes of the upper part of the volcanic series.

As to the fossils, one could not, indeed, expect to find them in the heart of a thick deposit of Pelean dust. They were found in some thin bands which alternate with the upper ashy series near its base.

In one respect the hypothesis here put forward relieves the geology of Snowdon from a difficulty that has been felt, namely, the great extent of the felsitic lavas. For the horizon has been traced over a tract of country some fifteen miles long by nearly ten in width, and even then it ends off in escarpments. Certainly it cannot be less than 150 square miles.[1] It is difficult to believe that acid lavas, with their well-known viscosity, could be continuous over such a distance. Mr. Harker suggests[2] that under water they might retain fluidity much longer than in air. But the fluidal structure, so well marked and so common in them, shows that after all they could not have been much less viscous than other acid lavas. If, however, the 'Lower Felstone' horizon be composed to any great extent of pyroclastic matter, the individual lavas may be comparatively limited in extent, and emitted from several vents, now concealed beneath each other's productions.

Finally, it may be remarked that ancient Pelean deposits will easily escape detection unless they are thick, for a foot or two of homogeneous unstratified tuff occurring in a volcanic series would hardly attract attention. Yet the violent outbreaks from Pelée itself of May 8th and July 9th, 1902,[3] even that which destroyed St. Pierre, seem to have left only two or three feet of dust upon the surface.

However these things may be, and whether the view advocated in this paper proves to be correct or not, it is certain that the work of Drs. Anderson and Flett, and of the French and American geologists who have described these phenomena, will give a fresh stimulus to the study of volcanic action, and lend a new interest to many of our ancient volcanic deposits.

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[1] Mr. Harker's estimate is much greater.

[2] "Bala Volcanic Series," p. 121, quoting Scrope and others.

[3] The mass ejected from the Soufriere was much greater.

IV.—THE RECENT GEOLOGICAL HISTORY OF THE BALTIC.
PART IV: CLIMATIC AND OTHER ISSUES.

By Sir H. H. HOWORTH, F.R.S., F.G.S.

IN the first part of this series, p. 313, I referred to the recent invasion of the Eastern Baltic by the ***Mya arenaria***, as first pointed out by Dr. Nathorst. Dr. Petersen has called my attention to an important paper by A. S. Jensen, which has apparently been overlooked by English conchologists, and I propose to condense his results, as they are very noteworthy from their geological lessons.

The shell has hitherto been treated as a typical Arctic shell. Thus Crosse and Debeaux write of its original home: " De l'océan Glacial arctique, qui parait être sa véritable patrie, elle est descendue dans les mers du nord de l'Europe, jusques et y compris la Manche et une partie de nos côtes de l'Océan " (Journ. de Conchologie, ser. III, iii, 254, 1863). Gwyn Jeffreys, in describing the shell, says, " The occurrence of this circumpolar shell-fish so near the tropic of Cancer probably indicates *the most southern limit in space of the glacial epoch* " (Brit. Conch., iii, 65, 66).

Jensen has most clearly shown that these inferences are quite unjustifiable, and that the shell has, in fact, no pretension to be an Arctic shell at all. He has proved that in every case where it has been reported from Greenland, Iceland, Spitzbergen, Nova Zembla, the river Yenissei, and Bering's Strait, it has been mistaken for *Mya truncata*, var. *ovata*, and that its true habitat is limited to the North Temperate Zone. It extends southwards in the Atlantic as far as South-West France in Europe, and South Carolina in America, and in the Pacific to Japan and China between lat. 30° and 40° N. In the European area it is found in the British seas, Belgium, Holland, Germany, Denmark, and Southern Sweden. Sars reports it from the whole Norwegian coast, while Knipowitsch does so from the warm section of the White Sea (see Jensen, " Studier over nordiske Mollusker," part i, Mya. Videns. meddel. Naturhist. for. i Kjöbenhavn, p. 150, 1900).

This is not all. The curious fact remains that while its distribution is as here mentioned, and while it is virtually certain that it has migrated, not from the north, but from the south or west, it should have entered, not only the Eastern Baltic, but apparently the Scandinavian waters generally, so recently. It is still a most valuable article of food, yet it has never occurred in the Danish kitchen middens, where so many other edible molluscs occur. Nor has it been found in the raised beaches or the deposits in the Isefiord, etc., in the southern part of the Cattegat, now known as the *Tapes* beds, which synchronize with the kitchen middens, so that, as Petersen argued, it doubtless invaded the Baltic waters in the recent human period.

Brögger has discussed its distribution on the Norway coasts, and argued forcibly that there also it is a recent arrival, since it does not occur in the raised beaches properly so called. In the Christiania fiord Professor Münster reported it from Smedholmen, near Brevik, in a bank which reaches down to only 66 feet above the sea-level, and Brögger urges that in this instance, as also in the case of Vallö, where it occurs at the sea-level, the shell has probably been thrown up by the waves, for it does not occur in the shell bank at Vallö nor in those at Tromö by Arendal. It has also occurred at Kadland, near Mandalselven, in conjunction with *Ostræa edulis*, *Cardium edule*, *Cyprina islandica*, *Tapes decussatus*, *Dosinia exoleta*, *Nassa reticulata*, *Polytropa lapillus*, *Gibbula cineraria*, *Turritella terebra*, etc. These shells must have lived in salt water and at a depth of some metres, while now the bed is found with only fresh water close by and above the sea-level. This, as Brögger says—and this instance is the sole one from Norway—shows that *Mya arenaria*, while living at the close of the *Tapes* time at the extreme south-western point of the land, had not arrived there at the close of the kitchen midden time (op. cit., p. 607).

A similar discovery of *Mya arenaria* was also made by Jensen in a raised sand beach at Nabsjert, in Vendsyssel, at a distance of 300 metres from the present coast and at a height of ·6 metre above the water. The shells measured 73 mm. in length (see Denm. geol., unter., 1st raekke, p. 279, n. 3). Brögger urges that this deposit dates from the same time as that at Kadland.

Brögger adds that further east, in the Langesunds and Christiania fiords, *Mya arenaria* only arrived in quite recent times (op. cit., p. 607). When Lyell wrote, in 1835, it had still a limited distribution in the Baltic, for he says, "This shell does not, I believe, extend so far north in the Gulf of Bothnia as Södertelje; I could not find it even at Calmar, and further south, at Sölvitzborg, it was rare and of very small size" (Phil. Trans., p. 10, 1835). Krajevnikof says all the specimens he had himself found were young.

Linnæus published the 10th edition of his "Systema Naturæ" in 1758, and there described the shell, p. 670, and gave it the name it still bears, and quotes as authority for it his own previous work, the "Wästgöten Reisa," p. 187, which was published in 1747, and where he names it *Concha subarenaceo marina* (under Concha he classes all bivalves). This seems to show that the shell was not known to him when he issued his earlier editions, and it was then probably limited to the western waters of the Baltic. As a proof of its rapid diffusion since, it may be well to give its present distribution in the Baltic, which is thus stated by Krajevnikof (Comptes Rendus Cong. Intern. Zool., Moscou, i, 151): Rugen, Stralsund, Greifswald, Stolper, the Bay of Dantzig, Calmarsund, Gotland, near Memel, Libawa, Windawa, near Riga, Dago, Oesel, Hapsal, Matzalwick, Réval, near Narva, and the Bothnian Gulf as far north as 62° 36′ N.

I have enlarged somewhat on the history of this shell in the north, because it has been made a kind of test of glacial conditions in England by C. Reid and others. Thus, in the Christiania Museum there are some specimens of it sent to Sars in 1866 by Crosskey and Robertson, and labelled "*Mya arenaria*, glacial clay, Kyles of Bute." On the ticket Sars has written "glacial" with a query, and in his memoir, Chr. vid. Selsk. Förh., 1867, p. 58, he says that "the shells had reached him so labelled, but from what Mr. Crosskey told him he doubted if they were not postglacial" (Brögger, op. cit., p. 609). Brögger, in fact, suggests that, like other molluscs in the Christiania fiord, it is a vagabond from American waters (id., pp. 608–9). In his synopsis of the Post-Tertiary beds (id., p. 650), he makes *Mya arenaria* the index and typical shell of the last and most recent stage in the littoral shell deposits in Scandinavia.

Secondly, in a passage in paper II of this series (see p. 352) I ventured to question whether in every case the raised shell-beds marked the permanent level of the water or only its transient passage after some impulse. This latter conclusion is doubtless sound in some cases, but it cannot apply to all, for in many of them the shells are clearly *in situ*. Thus Lyell expressly says that "in the gravel-pits at Solna, near Stockholm, the shells consist principally of *Cardium edule* and *Tellina balthica*, a great number of which have both their valves united." Again, speaking of *Mytilus edulis* at the same place, he says, "There has been a great accumulation of this shell in the stratum, but it is almost entirely decomposed, and is only recognized by the violet colour which it has imparted to the whole mass" (Phil. Trans., 1835, p. 5). The molluscs in this bed are therefore clearly *in situ*, and not remanié. It is 30 feet above the level of the Baltic.

In another bed at Bränkyrka, 70 feet above the sea-level, the shells are also clearly *in situ*, being described as embedded in a peaty soil containing fragments of wood, which peat, Lyell suggests, has been derived from seaweed, large accumulations of which he saw heaped up in a bay of the Baltic near Sölvitzborg, intermixed with similar species of shells (id., p. 6). Again, at the Blåbacken and near the Quarnbacken, Lyell describes beds of marl three feet thick, at a height of about 100 feet above the sea, as being remarkable for the violet colour imparted to them by the decayed *Mytilus* shells, and, he adds, "with the exception of the *Mytilus* the shells are generally very entire" (id., p. 7). Again, in a bed from 30 to 40 feet above the sea-level at Ulfva, on the banks of the Fyriså, he found a blue clay containing abundant specimens of *Tellina balthica* entire, with both its valves and the epidermis. *Mytilus edulis*, often much flattened and occasionally covered with the small white flustra so commonly attached to it in the Baltic, also occurred there (id., p. 14). From the opposite coast of Finland he cites the discovery of a section with marl of a violet colour at the height of 60 feet above sea-level at Nådendal, near Åbo, as also composed of the decomposition of *Mytilus edulis*, and as also containing perfect specimens of *Tellina balthica*, *Litorina litorea*, *L. rudis*, and *Paludina ulvæ* (id., pp. 22 and 23).

In all these cases there can be no question of remanié or rearranged beds, but of beds in which the molluscs actually lived, and which have been raised to the height of many feet above the sea-level since the shell-fish were living; and they testify unmistakably to a corresponding rise of the land, and not to a mere passing tidal wave depositing its burden. This evidence is, however, at first sight difficult to equate with the experimental evidence based on investigations specially directed to test whether the land has been and is now rising gradually from the sea. On this latter issue a very large and divergent testimony is available, for the polemic has now lasted for nearly two centuries, since Celsius wrote his well-known memoir in the Transactions of the Stockholm Academy.

There can be no doubt that, as in the case of all inland seas into which a large number of rivers laden with sediment are perpetually pouring, the accretion of sedimentary matters in the Baltic, especially its northern part, is causing not only a shallowing of its waters, but a great advance of the shore-line, which has gained enormously in consequence. Thus, as Lyell urges, it was pointed out by the opponents of Celsius that by the process of delta-making there had been a gain of half a mile in 45 years at Piteo, and of a mile in 28 years at Luleo, both in the Gulf of Bothnia ("Principles," 12th ed., vol. ii, p. 182). This cause, as in so many places in England, has induced the shallowing of harbours and the presence of shells far from the sea in the black clays forming a kind of delta deposit in so many places, etc., etc., and no doubt many of the alleged instances quoted to prove an actual rise of the land are attributable to this quite different cause. Others are due to test marks having been made on stranded boulders which have been actually moved into shallower water, and thus giving misleading evidence.

Another misleading element is the extreme variation in the normal level of the Baltic water. Although there is no actual tide in that sea, there are other notable causes of variation in its level. It has been ascertained that the great differences sometimes occurring in barometrical pressure cause a corresponding differential change of several feet in different parts of the sea. A similar effect is induced by the variation in the amount of fresh, and therefore light, water and of salt water, which causes a change between the Summer and Winter level of the sea in different parts, and, in fact, its level in the upper parts of the Bothnian Gulf has been experimentally shown by Mr. Wolfstedt to vary as much as 18 feet from that of its southern parts, and it no doubt again varies greatly according to whether the rivers and upper parts of the Bothnian Gulf are frozen or free.

This variation qualifies immensely the value of various experiments which have been made at different times by putting marks on exposed rocks, etc., at the sea-level and then examining them some years afterwards to see what changes have occurred. There is a double ambiguity in the process, one dependent on the controlling conditions of level when the mark was made, and the other on the similar conditions when it was afterwards examined. Hence the different and inconsistent results which have been drawn from this kind of evidence, and I am bound to say that Lord Selkirk's careful examination of the problem on the spot and his re-measurement of the different marks justified the conclusion he came to, namely, that "*they prove nothing*. The daily and weekly alterations in the level of the water caused by changes of the wind, and sometimes, I believe, by winds not felt at the spot where the change of level takes place, are so very considerable that anything that may have taken place in 30 years is almost imperceptible in comparison." After quoting some special cases to show the difficulty he says: "From this I infer that until the average level is more clearly ascertained, no inference can be drawn from these marks." After again referring to the possibility of the stones themselves having been raised or moved by shore ice, he quotes a Swedish report by Mr. G. Widell on the marks at Marstrand, who had come to the same conclusion as himself as to the uncertainty of any inferences to be drawn at present from these marks. Mr. Widell was the Rector of the Academy at Marstrand (Q.J.G.S., xxiii, 191–196).

If we turn from the experimental tests to evidence of another kind, there is a very extraordinary concurrence of testimony in favour of the conclusion that the older writers like Celsius, Von Buch, etc., who believed the changes in the Baltic to be still in progress and to have been progressive from early times until now, were mistaken.

Lyell, whose frank acknowledgment of the facts on the other side is always so notable, quotes the cases of the castles at Calmar, built in 1030, and of Abo in Finland, whose position near the sea makes it impossible to believe that there can have been much change of level since they were built. He refers again to the records about certain oak-trees at the fishing park of Fiskertorp on the Malar Sea, and declared by the keeper of the Royal forests to be 400 years old, and yet growing but ten feet above the level of the present tide (Phil. Trans., 1835, p. 13).

He also quotes a more critical test case, cited by the older Swedish writers: "On the shores of the Gulf of Finland were formerly some pines and oaks growing close to the water's edge; these were cut down, and by counting the concentric rings of annual growth, as seen in a transverse section of the trunk, it was demonstrated that some of them had stood there for nearly 400 years. Now," says Lyell, "according to the Celsian hypothesis the sea had sunk about 15 feet during that period, in which case the germination and early growth of these trees must have been for many seasons below the level of the water" (Lyell's "Principles," 12th ed., ii, 183). The argument, he adds, founded on the position of the trees, is, as Professors Lovén and Erdmann have lately remarked, unanswerable so far as it relates to a part at least of the Finnish coast (id.).

I may quote another piece of similar evidence which seems to me also very conclusive. On November 12th, 1903, Mr. W. Wermersten read a paper before the Students' Association at Upsala on an old deposit of the Stone Age in the south of the Island of Gotland. Parts of human skeletons as well as bones of dog, pig, and seal were found not more than 1 – 1·5 metres above the present sea-level, a proof that the elevation of the Isle of Gotland was all but finished at the end of the Stone Age (Bull. Geol. Inst. Upsala, vi, 280). This seems to me to present very important evidence that the upheaval of that island, like that of the mainland, was in the main, at least, before the Stone Age.

The same testimony is borne by the island of Biorkö in the Malar Sea, which contains a vast cemetery and other remains of the pagan Viking time, and can only have changed its level very slightly since the tenth century, which may be put therefore by the side of similar instances in the Cattegat. Standing in the midst of the fiord is the small island of Anholt. On the littoral beds, just above the water-line, are found remains of the Stone men, showing that the level of the island has not perceptibly changed since they were living. Again, historical documents show that the island of Saltholm, which is only slightly raised above the sea-level, has remained practically at the same level since the year 1280.

This kind of evidence, which is widespread, and might be much enlarged (and notably by the records of the various maritime towns in the Baltic lands, showing how stationary they have been for a long time), is very important when put beside the unmistakable evidence of the raised shell-beds, in regard to the level of these lands having been greatly raised in Middle and Northern Sweden since the invasion of the *Litorina* fauna; and it goes to show that the views of Von Buch and others in favour of uniformity in regard to this problem are not sustainable, but, on the contrary, that this undoubted movement of upheaval was largely limited to the times preceding or contemporary with the Stone Age, or at least to primitive times.

This invites the further question as to whether it was a gradual upheaval or, as I firmly believe, a spasmodic and intermittent one. The latter conclusion seems to follow from the fact that the shells do not occur in regularly sloping and continuous beaches, as we should expect in the case of an uprising coast of a sea where there is virtually no tide, but, as at Södertelje, at various heights in the strata separated by barren intervals (Lyell, op. cit., p. 10). The fact of the shells occurring in detached beds, and not being regularly distributed throughout the whole depth down to the sea-level, seems clear evidence that their deposition was intermittent and not gradual.

Another fact difficult to account for on any other theory is, that the shells in the shell-beds, instead of gradually increasing in size and gradually losing their distorted forms as we get higher in the beds, until we reach a layer where they are of the normal size and appearance of those in the outer sea, are described as all dwarfish in size, just as they are found in the brackish water of the neighbouring Gulf of Bothnia, and the whole assemblage of shells such as characterizes the Baltic. Recent writers, although they have noticed a certain dwarfing of the living forms when compared with those in the raised beds, yet declare the latter to be much dwarfed and distorted, and I know of no specimens found in the raised beaches of a normal size.

I have ventured to draw another inference in regard to the abruptness of the upheaval of the shell-beds from the abruptness of the gap and want of conformity between the *Ancylus* and the *Litorina* beds. The fact of this unconformity is emphasized by the Swedish geologists. Thus Nathorst says that "De Geer, in his more recent papers, has pointed out that in many places in the peninsula of Upland, especially in the neighbourhood of Upsala and Stockholm, there is a discordance between the *Litorina* clay and the lighter-coloured Baltic clay of Munthe on the one hand and the *Ancylus* clay on the other. According to Hogbohm and Munthe, again, the former clay in the district of Upsala is in certain places separated from the *Ancylus* clay by a layer of sand or a clay-like sand formation of a depth ranging up to several metres; there can therefore be little doubt that there is a breach of continuity between the beds, thus representing an abrupt change and involving more or less troubled conditions" (Nathorst, "Sueriges Geologi," p. 268).

Numerous additional facts, therefore, are available to support the not generally accepted conclusion that the rise of the Baltic lands not only took place in the main and perhaps entirely in primitive times, but that the same rise was intermittent and not gradual, and was rapid and sudden and not continuous and slow.

Let us now turn again to the sinking in the southern Baltic area which broke down the Baltic breach. This has been thought by some of the northern geologists to have been a very general phenomenon, in which a large part of Scandinavia had a part. As attested by the evidence, however, it was very local, and involved only the narrow seas separating Skäne from Mecklenburg and the mainland generally.

To the evidence already cited of the fact itself I should like to add some more recent testimony. The 2nd part of the 3rd series of the Danish Geological Survey publications is a synopsis of recent progress in geology in Denmark by Ussing, who mentions instances of submerged peat bogs recently found at Graadyp, north-west of Fanö; in the dock works at Esbjerg, and Aarhus, and at various places near Copenhagen and Bornholm. A famous example was that disclosed in 1899 during the drainage works at Copenhagen and at a place where the water was 40 feet deep. Ussing says expressly that the position of this submerged peat bog in relation to the depth of the Sound shows that it may have been once a part of the land communication between Copenhagen and Malmö (op. cit., p. 313). As he says, "Som sammenliguet med Öresundets Dybdeforhold antyder, at der maa have vaeret landfast Forbindelse mellem Kjobenhavn og Malmö."

The deposit at Esbjerg, of which a very good profile is given by Hartz, shows a bed of turf two inches thick covered by 1·5 of sand, etc., including a layer of sand with shells. The bed of turf lay 4·5 metres under high-water mark.

In addition to peat mosses, submerged trunks of trees have also occurred in similar localities; thus in indamming land at Vigero, 3,000 feet outside the south coast of the Odense fiord, stumps of trees were found rooted in the so-called moraine clay, including those of a fair-sized oak wood. The level on which the trees grew is now submerged to the extent of two feet. In the old harbour of Copenhagen were also found remains of an old wood 20 feet below the surface (Ussing, op. cit., p. 313).

Another striking proof of the same fact is the submerged and sinuous channel in the Odense fiord, or the Sound as we call it. The course of this channel has been mapped out on one of the plans in a volume of the Transactions of the Copenhagen Geological Survey. From this it is clear that this furrow forms a continuation of the Odense river, and its depth in certain places is more than 11·3 metres, or 36 feet, and it must, as Ussing says, be deemed the former bed of that river. A proof of this is forthcoming in the fact that the deepest tracks of the furrow are not where the fiord is narrowest, and where, therefore, the scour is the greatest. Not only so, but the channel itself, instead of having been the result of scouring by a race or tide, has been and is being filled up. Its bottom is covered with more than five metres thick of *Cardium* mud, while outside the channel itself the deposit is not more than one metre, which proves that here we have to do with an old furrow or channel which is being choked up and not cleared out. Similar conditions are found in the smaller and subsidiary channels and in those which run into the principal branch, forming, there can be little doubt, the drainage of the area of the Sound when all or the greater part of that area was dry land.

Again, I have ventured to argue in a previous paper that the great collapse or breach, by which the Baltic was converted from a fresh-water lake to a brackish sea, was, like the corresponding upheaval further north, rapid or sudden, and took place while man occupied the country. This enables us approximately to date it.

According to the latest opinion of Dr. O. Montelius, the Swedish archæologist who has devoted the most time to the study of primitive man in Scandinavia, the Bronze Age in Sweden began about 1700–2000 years B.C. This is an approximation deduced from a comparison of the shapes and ornaments on the bronze objects in the northern lands with those of the Mediterranean, whose probable date we can fairly fix, and it takes us back 3600–3900 years from the present time for the commencement of the Bronze Age in Scandinavia.

The preceding Neolithic age, judging from the enormous number of monuments and remains it has left in the North, must have been very prolonged. As many as 36,000 finds of the post-kitchen-midden Stone Age had been reported from Sweden alone up to the year 1874. The Neolithic age in Denmark has been divided into two sections, one comprising the remains of the kitchen midden times, i.e. of the older race of new Stone men who did not use polished tools and had no domestic animals except the dog, and a second era during which men used polished stone axes and more shapely and elaborate chipped ones, and kept domesticated animals.

According to the evidence, as we have seen, the breach in the Baltic bridge took place after the kitchen midden time and during the succeeding period of the Neolithic age. That is a *terminus a quo* from which we may roughly calculate the time that has elapsed. Von Baer, who was the first, I believe, to make such a calculation, put the date of the breach at 5,000 years ago. He based his calculation, however, on the uncertain element of the rate at which the Baltic lands were supposed to be now rising.

Dr. Brögger, in his book on the Mollusca of the Christiania Fiord, bases his calculation on the archæological evidence, and puts it at 8,000 years ago.

If we take the mean of these two calculations, say 6,500 years, we shall perhaps roughly approximate to a tentative date since which salt water has been flowing into the Baltic basin, and introducing partially marine conditions there, while the fresh water has been flowing out in a large stream into the Cattegat and destroying the oysters and associated shells there, initiating the *Litorina* sea on the one side and pushing back the *Tapes* sea on the other. This double action of the catastrophe seems plain from the evidence, and I therefore cannot agree with De Geer and Brögger when they equate the *Tapes* and Oyster period in the southern Cattegat with the *Litorina* stage of the Baltic, instead of with the *Ancylus* stage. The *Litorina* time was, in fact, the inception of the present condition of things in the Baltic, as the contemporaneous *withdrawal* of the *Tapes* fauna initiated the present condition of things in the Cattegat.

The next question is to ascertain what climatic changes we can predicate in Scandinavia during the interval bounded by the beginnings of the *Litorina* time and the close of the *Tapes* time on the one hand and the present day on the other. First let us look at the question from an *a priori* view.

Ekholm, in a paper in Ymer, Heft iv, p. 377 ff., translated in the 27th volume of the Quart. Journ. of the Meteorological Society, No. 117, January, 1901, has argued that about 8,000 years ago the Summer temperature in Mid Sweden would be enhanced to an extent of 2 degrees Centigrade, due to the fact that the inclination of the ecliptic would then be at its minimum, and further that since that date it has been growing slightly more severe.

In the first two chapters of my new book, "Ice or Water," I have given an elaborate analysis of the astronomical conditions affecting climate, and notably of changes affecting the inclination of the ecliptic, showing that the problem is a good deal more intricate than has been generally thought, and that it has to be qualified by many conditions. I do not, however, propose to raise any issue with Ekholm on the matter, and he is mathematically approximately right.

Brögger has, as we have seen, tried to equate the archæological evidence with the theory of Ekholm by giving a higher value to the length of time during which the second stage of the Neolithic age persisted than I have here tentatively given. I am not constrained to question his argument and conclusions either, which, like mine, are merely tentative.

He goes on to argue further that, during the period since the *Litorina* sea was initiated, the climate of Scandinavia has become distinctly colder, if it has changed at all, and he even seems to adopt Ekholm's suggestion that it has become colder to the extent of reducing the midsummer temperature to the extent of 2 degrees C.

Whatever the quantitative value of the suggestion, the external and supplementary evidence seems to me to amply sustain the main contention of the Norwegian writers, and to show that for a long time past, whether it be for 6,000 or 8,000 years, and not impossibly the latter, the climate of Scandinavia has been growing colder and not growing warmer.

Let us shortly turn to this supplementary evidence. In the first place, then, it seems to me that the dominating climatic factor in terrestrial areas depends very largely upon their latitude, an element which is fixed, and their elevation above the sea-level, which is variable. The higher the land, especially in high latitudes, the lower, *cæteris paribus*, the mean temperature. This is an elementary axiom of meteorology. Inasmuch as the Scandinavian lands in the *Litorina* time were more submerged than, and not so high above the water in the Central and Northern Baltic as, they are now, it follows inevitably that the mean climate of the land, in so far as it was affected by its height above the sea-level, was warmer in the *Litorina* time than it is now.

Secondly, in northern latitudes salt water has a higher mean warmth than fresh water; the latter, again, freezes much more easily, and supplies, therefore, a great refrigerator in Winter, when the salter water is more open. Inasmuch as *the* feature of the *Litorina* time in the Baltic was the greater salinity of that sea, it follows that as the Baltic has been becoming less saline it has also become cooler, so that in both respects the tendency has been in the direction of a severer climate.

A third element, working in the same direction, is caused by the fact that the inflowing water from the North Sea is itself warmer as a whole than the outflowing water from the Baltic, and as the former was present in larger proportionate quantities in the *Litorina* time than now this again confirms the same conclusion.

Let us now turn to the fauna and flora of Scandinavia and see what it tells us. There cannot be a doubt that since the Baltic breach took place the fauna and flora of the Scandinavian peninsula and of the Baltic islands has not been in a position to receive fresh recruits and accessions from beyond the sea. The peopling of such isolated areas by the vagabonds of the biological world seems to me to be a quite fantastic idea, and the number of land plants and animals (other than regular or irregular migrants from the classes of birds and insects) which have reached the lands in question since the land-bridge was broken down must have been insignificant.

We may accept the present fauna and flora of Scandinavia and the Baltic islands, therefore, as a fair measure of what the climate of

those lands was when the Baltic bridge was broken. There may have been a partial extinction of forms due to various causes, but the climate of the land was at least tolerant of all the various living beings which now exist there and which must have reached there overland.

It is necessary to emphasize this because the position has been somewhat sophisticated by the efforts of the Northern botanists to press certain local conditions into a general law. That general law seems to me inapplicable, at all events, to the period which has elapsed since the *Litorina* stage of the Baltic history began. It has **been often affirmed, for instance, on the a**uthority of Steenstrup, that **the bogs of Denmark afford a kind of** thermometrical standard of **change of climate, marked by the success**ion of the forests embedded **in them. At the bottom of all are pine** trunks. The pine has long **ceased to grow in Denmark, and is not** known traditionally there. **Above the pines come oak-trees. The oa**k is also an infrequent tree **in Denmark. The present forests of the country are composed of beeches, and it is argued that this is the general law of succession of these trees, the fact being that when we go to Norway we find that the oaks underlie the pines. Thus, as Professor James Geikie says, "Mr. Blytt has recorded that in South-Western and Southern Norway oaks and alders occur at the bottom of the bog, which is of variable thickness and formed of aquatic and marsh-loving plants. Above this under portion comes a second forest layer, composed chiefly of pines, which are, in their turn, buried under a second bed of sphagnum peat. Lindsberg and others tell us of exactly similar** phenomena in the peat bogs of Scania. There, as in Norway, the bottom forest beds are formed of leafy trees, while the upper ones are chiefly coniferous" ("Prehistoric Europe," pp. 528–9). Professor Geikie has tried to get over this difficulty, but quite unavailingly (id., pp. 5, 35, 36). The fact is the succession of these trees was long ago shown to be, not a test of climate, but of another thing altogether. When the forest fires take place in the barren lands of America or in Siberia, it is found that a forest of leafy trees nearly always succeeds one of coniferous trees, and *vice versâ*, and the explanation is that each class of tree more or less exhausts the special products of the soil suited to it, and thus gives a chance to its rivals to supplant it. Again, the forests of beech which now grow so largely in Scania and Denmark do not grow over the remains of the buried pines and oaks; these lie in bogs whose surface sustains a growth of birches. The beech does not like such soil as bog earth, the deep clay in which the oak luxuriates or the sand wastes where the pine thrives, but loves chalky and marly soils and gravels.

I take it that the distribution of the trees in these areas was always rather dependent on the constituents of its subsoil and on whether it was for the time being drained or very wet than otherwise, and was always dominated by local circumstances. Thus the beech, instead of being quite a new-comer into the North, was there from early times, but did not thrive on bogs or in land where clay soil abounds, and therefore the remains of beech do not naturally occur in the peat, while the oaks and pines succeeded each other on such ground irrespective of any special order, and rather in accordance with accident than law and controlled by local and sporadic conditions.

What we know of the distribution of the beech in these countries is significant. It has been treated by some as quite a late arrival. It is, on the contrary, an old tree there. Thus Blytt says of it: "Its discontinuous distribution in Norway shows that it is a long time since it wandered thither. Along the whole west coast it only grows wild at Samistrand, north of Bergen. It also has a scattered distribution east of Lindesväs. That it is truly wild with us is shown, among other things, from the large number of lichens peculiar to beech woods which are found in the beech woods of Norway" ("Ueber zwei Kalk-tuff bildungen in Judbrandsdalen": Engler Bot. Jahr. Beiblatt, p. 18, 1892).

This is remarkable testimony, since it shows that the beech is an old denizen of Norway, and we can hardly doubt that it was living there at the time of the Baltic breach, otherwise it must have been introduced by man, which is incredible, for it could not cross the Sound and the Belts, nor are its seeds adapted to aerial flights. It is also old in Denmark, for R. Sernander reminds us how, in 1873, Hansen described in a peat-bog, near the lake of Kjedle, a mass of leaves and a specimen of the fruit of the beech at a depth of 6 feet (Engler Bot. Jahr., xv, 85). Jensen also cites remains of the beech as occurring with those of the pine, oak, hazel, etc., in the marine beds of Randsbaek, in Vendyssel, in Jutland (see Denm. geol., unter., 1st raekke, iii, 308). This proves that even in Denmark the beech is a very old tree, and that local circumstances have combined to produce the particular succession in certain places as described by Steenstrup.

I therefore venture to question the feasibility of separating the most recent period of Scandinavian history into a succession of epochs marked by the prevalence of a particular tree. That may be possible at an earlier horizon, but not since the *Litorina* sea was initiated. The attempt means applying quite local conditions to illustrate widespread geographical problems.

There is, however, botanical evidence of another kind which points the same moral as the evidence already adduced, and is in favour of the trend of climatic change having during recent millennia been from a warmer to a colder stage.

There is evidence from the fjelds in Norway that the forests in the upper ground are shrinking and the trees in their upper stretches are dying, just as the same thing is happening in certain districts in the Alps. The nomenclature of the northern part of the country also affords evidence that since the human period there has been a corresponding shrinkage in the area where cereals can grow.

The botanical evidence from Scandinavia, therefore, fully sustains that deduced from the mollusca of the Cattegat by Petersen and others, in favour of the conclusion that the climate of the peninsula has been growing colder in the most recent geological times.

This is an important and ominous fact to be remembered by those who, looking across the horizon separating us from the penultimate changes in the world's history, see there a portentous ice age, swathing half the northern hemisphere in ice, which actually, in the eyes of some, crept up to the very threshold of our time. It is clear that the facts and conclusions here discussed, so far as they go, give no kind of support to such an hypothesis. They point unmistakably the other way, namely, to a recent deterioration instead of an amelioration of climate. We must go much further afield than the last 6,000 or 8,000 years if we are to find any substantial basis for that theory in Scandinavia, and *a fortiori* in lands, like Britain, situated in lower latitudes.

V.—NOTE ON THE SPECIES OF *PALÆOMASTODON.*

By C. W. ANDREWS, D.Sc., F.G.S., British Museum (Natural History).

DETAILED examination of the remains of fossil mammals from the fluvio-marine beds (Upper Eocene) of the Fayûm has, in several cases, shown that the number of species of the various genera has been underestimated. This is especially the case with ***Palæomastodon***, of which originally only one species, ***P. beadnelli***, was recognised. Subsequently another form, ***P. minus***, was named, and now it has become necessary to establish at least two other species, to one of which probably by far the greater number of the specimens collected must be referred.

The species of *Palæomastodon* fall into two sections, in one of which the posterior end of the symphysis of the mandible is situated considerably in front of the level of the anterior premolar, while in the other it is only very little in front of that point. The first group, moreover, is distinguished by the comparative simplicity of the molars, in which the accessory cusps are scarcely at all developed, and by the small size of the talon of the last lower molar; into this subdivision the original species, *P. beadnelli*, falls, together with a much smaller form for which the name *P. parvus* is now proposed. The type-specimen of this new species is the right ramus of the mandible, with the premolars and molars *in situ*, though somewhat crushed. The posterior border of the symphysis is about 5·5 centimetres in front of the anterior premolar, which at once distinguishes this form from the two species belonging to the other group. The third molar consists of two transverse ridges, each composed of two tubercles, and a smaller third crest consisting of a large outer and a small inner tubercle; there is no talon unless this third ridge is so regarded; there is a small intermediate tubercle in the anterior valley, but otherwise accessory cusps are wanting; the enamel is very smooth, and the cingulum is practically absent. M. 2 is trilophodont, but the last ridge is smaller than the others; it consists of an outer, larger and an inner, smaller cusp. The dimensions (in centimetres) of the molars in this specimen are :—

	Length.	Breadth.
m. 1	3·9	3 (app.)
m. 2	4·4	3·2
m. 3	4·5	3·2 (app.)

So far as its molar pattern is concerned, both this species and *P. beadnelli* seem to be more primitive than the other species referred to below, but on the other hand *P. beadnelli*, by its larger size, and both it and the present species in the elongation of the mandibular rami, appear to be more specialised. This intermingling of primitive and specialised characters is to be expected in a group represented by several contemporary species and undergoing rapid change in a given direction, the final product, in this case *Tetrabelodon* or some closely allied type, being the resultant of the various modifications, and here combining the great elongation of the mandible with increased complication of the teeth.

The second group, in which the posterior border of the mandibular symphysis is immediately in front of the anterior premolar and the molars are complicated by the addition of accessory cusps, also includes two species. Of these one, *P. minor*, has already been described (GEOL. MAG. [5], Vol. I, p. 115); the other is a much larger form, and is important as being probably the commonest of all the species; for this the name *P. wintoni* is suggested, in honour of Mr. W. E. de Winton, by whom the expenses of my third collecting trip to the Fayûm were defrayed. It is considerably larger than *P. parvus* and *P. minor*, but smaller than *P. beadnelli*. From this last species it is also distinguished by (1) the extension back of the symphysis so that its posterior end is only just in front of the anterior premolar; (2) the position of the mental foramen on the side of the symphysis instead of behind it; (3) the greater complication of the molars and their greater length in proportion to their width; the last lower molar consists of three transverse crests and a distinct talon. The type-specimen is a mandible with the incisors and posterior molars *in situ*. The dimensions (in centimetres) of this specimen are:—

Length from condyle to tip of symphysis	74
Width of symphysis at narrowest	8
Length of symphysis	21

The dimensions of the teeth are:—

	Length.	Width.
m. 2	5·5	3·5
m. 3	7·4	4·4

Probably the greater number of the *Palæomastodon* remains so far collected belong to this species, but in the absence of associated series of bones it is not possible to be sure of this, although it appears that no mandibles of the type of *P. beadnelli* have been obtained in the pits from which most of the specimens have been collected.

The above-named species will be described more fully and figured in the forthcoming "Catalogue of the Tertiary Vertebrata of the Fayûm."

NOTICES OF MEMOIRS, ETC.

BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE SEVENTY-FIFTH ANNUAL MEETING, HELD IN SOUTH AFRICA, AT CAPE TOWN AND JOHANNESBURG, AUGUST 15TH TO SEPTEMBER 1ST, 1905.

LIST OF PAPERS READ IN SECTION C, GEOLOGY.

Professor H. A. MIERS, M.A., D.Sc., F.R.S., F.G.S., President.

Read at Cape Town, August 16th to 18th.

A. W. Rogers.—Lecture on the Outlines of the Geology of Cape Colony.

Professor W. J. Sollas.—The Continent of Africa in relation to the Physical History of the Earth.

Professor R. Broom.—The Classification of the Karroo Beds of South Africa.

J. Lomas.—Report of the Committee on the Fauna and Flo[illegible] of the Trias of the British Isles.

P. F. Kendall.—Report of the Committee on Erratic Blocks of the British Isles.

A. R. Dwerryhouse.—Report of the Committee on the Underground Waters of North-West Yorkshire.

Dr. Wheelton Hind.—Report of the Committee on Life-zones in the British Carboniferous Rocks.

H. C. Schunke-Hollway.—The Physical Geography of Cape Colony.

A. W. Rogers.—Glacial Periods in South Africa.

Professor A. Penck.—Changes of Climate as shown by Movements of the Snow-line and Upper Tree-Limit since Tertiary Times.

Professor W. M. Davis.—The Sculpture of Mountains by Glaciers.

R. N. Rudmose Brown.—The Scottish Antarctic Expedition's Visit to Diego Alvarez or Gough Island.

Professor A. Young.—On a Subterranean Tide in the Karroo.

A. L. du Toit.—The Stormberg Formation in Cape Colony.

J. Milne.—Recent Advances in Seismology.

H. T. Ferrar.—On the Geology of South Victoria Land.

E. H. L. Schwarz.—Baviaan's Kloof: a Contribution to the Study of Mountain Folds.

J. W. Stather.—Report of the Committee on the Fossiliferous Drift-Deposits at Kirmington, Lincolnshire.

Read at Johannesburg, August 29th to September 1st.

PRESIDENT'S ADDRESS. (See GEOL. MAG., pp. 417, 473, 519.)

Professor J. W. Gregory.—On the Rhodesian Banket.

Professor J. W. Gregory.—The Indicators of the Goldfield of Ballarat: a Study in the Distribution of Gold Pockets.

Professor R. Beck.—On the Relation between Ore Veins and Pegmatites.

Dr. A. P. Coleman.—Magmatic Segregation of Sulphide Ores.

Professor G. A. J. Cole.—Marginal Phenomena of Granite Domes.

H. S. Harger.—The Diamond Pipes and Fissures of South Africa.

F. P. Mennell.—Relation of the Igneous Rocks to the Crystalline Schists.

G. W. Lamplugh, F.R.S.—Report on the Batoka Gorge of the Zambesi, and the Surrounding Country between the Victoria Falls and the Confluence with the Deka River. (See p. 529.)

Professor A. Penck.—Glacial Deposits of the Alps.

H. Kynaston.—Recent Work of the Transvaal Geological Survey.

Dr. F. H. Hatch.—The Correlation between the Pre-Karroo Rocks of the Transvaal and those of Cape Colony.

Dr. F. H. Hatch.—On an Instrument for Surveying Boreholes.

W. Anderson.—On the occurrence of Fossiliferous Rocks of Tertiary Age in Natal and Zululand.

S. S. Dornan.—The Geology of Basutoland.

C. Baring-Horwood.—The Dolomite Formation of the Transvaal.

W. Anderson.—On the occurrence of Fossiliferous Rocks of Tertiary Age in Natal and Zululand.

E. T. Mellor.—Evidences in the Transvaal of Glacial Conditions in Permo-Carboniferous Times.

G. W. Lamplugh, F.R.S. — Note on the occurrence of Dwyka Conglomerate at Kimberley Mine.

H. S. Harger.—The Diamond Pipes and Fissures of South Africa.

Dr. J. T. Carrick.—Geology of the West Rand.

F. P. Mennell.—Relation of the Igneous Rocks to the Crystalline Schists.

E. Heneage.—A Consideration of the Archæan Period of North America and South Africa, with reference to Mineral Occurrences.

Photographs of Russian fossil reptiles, lent by Professor Amalitzky, of Warsaw, were on exhibition in the Committee-room of Section C.

The following is a list of the titles of papers bearing upon Geology which were read in other Sections of the British Association in South Africa:—

SECTION A.—MATHEMATICAL AND PHYSICAL SCIENCE (Aug. 30th).

Professor J. Milne, F.R.S.—Report of the Seismological Committee.

Professor J. Milne, F.R.S.—Recent Advance in Seismology.

SECTION B.—CHEMISTRY.

Professor P. Hahn.—A South African Mineral Spring.

SECTION D.—BIOLOGY (ZOOLOGY).

Report of the Committee on the *Index Animalium.*

Professor R. Broom.—On the Origin of Mammals.

Professor W. B. Scott.—Convergent Evolution as illustrated by the Litopterna—a group of fossil Ungulata in Patagonia.

SECTION D.—BIOLOGY (BOTANY).

A. C. Seward, F.R.S.—The Fossil Floras of South Africa.

SECTION H.—ANTHROPOLOGY.

Report of Committee on Lake-Village of Glastonbury, Somerset.

J. P. Johnson.—Stone Implements in South Africa.

REVIEWS.

I.—Geological Survey of England and Wales.

The Geology of the Country South and East of Devizes. By A. J. Jukes-Browne, B.A., F.G.S. pp. 61. (1905. Price 1*s*.)

IN this memoir, which is accompanied by a geological map (Sheet 282, price 1*s*. 6*d*.), very clearly printed in colours, we have a description of a large part of Salisbury Plain, including the War Department land between Tidworth and Bulford, and also of the Vale of Pewsey as far east as Burbage. The general structure of the area is shown in a line of coloured section, engraved at the foot of the map, and by a column of strata, drawn to scale. Beds from the Oxford Clay to the Reading Beds and alluvial deposits are depicted on the map and described in the memoir. There are, however, some missing strata; the Corallian beds, for instance, do not appear at the surface, as they are cut out by a fault; and there are striking evidences of unconformable overlap or overstep where the Lower Greensand crosses the outcrop of the Portland Beds, and where the Gault and higher Cretaceous rocks extend over the Lower Greensand on to the Jurassic strata. The remnants of Reading Beds rest unconformably on the Upper Chalk. The district is one that was described in part by the old masters, Lonsdale and Fitton, while the country around Devizes is especially associated with the name of William Cunnington, who amassed a rich collection of fossils, many of them now in the British Museum and others in the Devizes Museum.

Full particulars are given of the strata and their fossils; the account of the Cretaceous rocks, which occupy most of the area, extending over five of the eleven chapters. There are notes also on the economic deposits, including the Seend iron-ore, which is no longer worked, and on the springs and water-supply.

With the exception of the valley deposits there is very little 'Drift,' the few tracts of clay-with-flints being remarkable over the wide expanse of the Chalk downs. Mr. Jukes-Browne expresses his opinion "that this deposit has been formed almost entirely from Eocene material, and that it only occurs at places where the present surface is not far below the ancient plane of erosion on which the lowest Eocene deposits were laid down."

II.—Geological Survey of Canada.

By Robert Bell, I.S.O., M.D., D.Sc., LL.D., F.R.S. Summary Report for the Calendar Year 1904. 8vo; pp. 392 and xxxviii, figures and maps. (Ottawa: S. E. Dawson, 1905.)

THIS report deals in a general way with the operations of the Geological Survey Department for the year ended 31st December, 1904. The first part (pp. i–xxxviii) contains a brief résumé of the work carried on during that year at headquarters, consisting of the preparation of the numerous publications issued by the department, the making of the maps, matters relating to economic geology, the care of the collections, etc. The field-work ("officers' reports") fills up the rest of the volume.

Mr. R. G. McConnell describes his exploration of the new goldfield of the Kluane district, Yukon. This embraces Alsek River, Kluane Lake, and the north-eastern slope of the St. Elias range. The last has become familiar to geographers through the Italian expedition of 1897 under the Duke of the Abruzzi, when an ascent of Mount St. Elias (the highest point in Alaska) was made. A great variety of massive igneous rocks occur in this range. Unlike the Rocky Mountain range, there is no evidence of overthrust faulting, reversing the normal sequence of the beds, though they are highly tilted. The gold is of local origin, and is derived from the quartz veins cutting the Kluane schists. The production is at present small, but worked by more economical methods there seems promise of future success.

Mr. Joseph Keele examined the Duncan Creek mining district, Stewart River, Yukon territory, where also 'coarse' gold, derived chiefly from the bed-rock (quartz and mica-schist), is widely distributed. Maps accompany both these reports.

Dr. R. W. Ells and Mr. R. A. A. Johnston were occupied in working out the geological structure of the Nicola Coal-basin, British Columbia, with special reference to the occurrences of coal and the ores of iron and copper. The rocks of this area were described in 1877–8 and in 1894 by Dr. G. M. Dawson, who gave the name "Nicola Series" to the volcanic rocks (Triassic) and "Coldwater Group" to the sedimentary (Tertiary) rocks. The former consist of diabase, porphyrite, rhyolite, andesite, felsite, and agglomerate, with which, locally, large masses of granite of later date are associated. The sedimentary rocks comprise conglomerate, sandstone, and grit, shale and beds of coal, which are in some places lignite of fair quality, as at Similkameen, but in other places they pass into bituminous coal, as in the Nicola Valley, where they form deposits of great value. A map, coloured geologically and on a scale of one inch to one mile, is appended to this report.

Professor R. W. Brock continued his work in the Lardeau mining district, British Columbia, begun in the previous season (1903). He describes the physical geography, glacial geology, solid rocks, and mining geology of the district. The value of the mining seems to be rather prospective than present. The ores found are gold, silver, and lead.

Dr. R. A. Daly contributes a report on the geology of the western Cordillera, along the line of the international boundary (49th parallel).

A few pages are occupied by Professor John Macoun, the well-known botanist to the Survey, in a report upon the natural history of the "National Park" (Rocky Mountain Park), including also its botany.

Mr. D. B. Dowling continued his examination of the coalfields of the Rocky Mountain region adjacent to the line of the Canadian Pacific Railway, where he has made important discoveries of coal-seams. This report is accompanied by a coloured geological map of the Costigan Coalfield, Alberta, and other illustrations.

During the Canadian Government expedition to "Hudson Bay and Northward" under Mr. A. P. Low, some observations were made as time would allow (the object of the expedition being other than scientific) upon the geology and natural history of the coast and adjacent regions. The scientific results of this expedition indicate the importance of the presence of trained scientific men on such expeditions, if full advantage of them is to be taken. The western coast of Hudson Bay was geologically examined from the head of Chesterfield Inlet to that of Wager, and track surveys made. The western shore of Southampton Island and Ungava Bay were similarly examined, a survey of 2,041 miles being in all accomplished. The predominant rocks observed on Southampton Island were a coarse granite-gneiss with broken bands of diabase and chloritic schists. These rocks are overlain by Silurian limestone in places. On the eastern shore of Ungava Bay the rocks are all Archæan, principally granite-gneiss, with a large amount of basic irruptives, such as gabbro and anorthosite. Large collections of rocks, fossils, the northern mammals and birds, as well as fishes and marine invertebrates, were made, as also Arctic plants. The expedition occupied 14 months from the time of leaving Halifax to its return to that port.

Mr. Charles Camsell made geological and the necessary topographical surveys in Eastern Manitoba and those parts of the country between Lake Winnipeg and the Severn River. This area is occupied by rocks of Archæan age, principally granites and gneisses. Mr. Camsell traced the boundaries of the eastern extension of the Huronian area around Red Lake, and also discovered some additional small areas of Huronian rocks.

Mr. Wm. McInnes followed up his interesting explorations of the previous year in the extensive and hitherto almost unknown region of the Winisk River and surrounding country, lying to the south of Hudson Bay proper. His work adds materially to a knowledge of the rock-formations of this region.

Mr. W. J. Wilson worked in the country lying northward of Long Lake, north of the central part of Lake Superior, including the head-waters of some large branches of the Albany River. He traced out a further extension of a known area of Huronian rocks in which gold, copper, and iron ores may eventually be found.

Mr. Owen O'Sullivan surveyed and explored the southern and western coasts of James Bay as far north as Cape Henrietta Maria. These coasts, occupying the central part of the map of Canada, had not previously been very accurately delineated. The work was undertaken to supply this want, and at the same time to observe and record the geological features of this region. A map of the coastline surveyed is added to the report.

Messrs. E. D. Ingall and Theo. Denis continued the detailed geology of the typical Huronian area in the Bruce Mines district of Algoma. A map illustrating the geology of this area accompanies the report, which, in addition to the geological interest attached to it, is expected to be of service in the future search for copper deposits.

Dr. A. E. Barlow has an interesting report on Corundum in Ontario. The occurrences of this valuable mineral in Canada are confined to a series of eruptive rocks frequently presenting a well-marked foliation, in close accordance, as a general rule, with that of the surrounding granites and diorites (Laurentian gneisses). The corundum-bearing rocks are of syenitic or gabbroic type. "The simplicity and, at the same time, completeness of the Canadian occurrences of corundum, combined with the fresh and unaltered character of the associated minerals, at once removed all doubt as to the pyrogenetic origin of this mineral, showing clearly its development as a primary constituent from a highly aluminous silicate magma, as one of the first products of its crystallization." It is worthy of note that Canada is now the largest producer of corundum in the world.

Dr. Barlow, associated with Dr. G. A. Young, continued work in the Temagami Lake region.

Professor W. A. Parks investigated a part of the country on the western side of Lake Timiskaming and thence northward to some of the branches of the Blanche River in connection with the recent discoveries of silver and cobalt in that district. He mapped out the rock-formations of the region, and indicated the zone in which the two metals occur.

Mr. A. F. Hunter was occupied in the district from Orangeville northward to Thornbury, Ontario, in tracing the interesting high-level shore-lines along the flanks of the Blue Mountain escarpment south of Georgian Bay (Lake Huron).

An important task was begun by Professor Ernest Haycock in working out the detailed geology of the upper Laurentian series in the south-western part of the county of Ottawa. This area contains a great variety of crystalline rocks, which Professor Haycock divides into nine groups, consisting of gneiss, crystalline limestone, quartzite, altered greenstone, etc. After further work it is intended to issue a map of the district on a scale of one inch to one mile, to show the geological structure and the distribution of the rocks in a manner similar to that done by Sir William Logan on his map of a typical area of upper Laurentian rocks in the county of Argenteuil.

The geology of part of the county of Ottawa engaged the attention of Mr. J. F. E. Johnston and proved to be of a very intricate nature. The Lièvre River and Templeton phosphate district are included in the area examined.

Dr. Robert Chalmers investigated the surface geology of the Gaspé peninsula and of the country along the south side of the lower St. Lawrence from Gaspé south-westwards towards the city of Quebec. Thence he worked northward to Lake St. John and the valley of the Saguenay, noting that there are a number of interesting problems relating to glaciation, geomorphic changes, altered drainage-lines, etc., offering themselves for investigation and study in this region.

Dr. J. A. Dresser continued the work of previous years by examining and defining the copper-bearing rocks of the Eastern Townships (Sherbrooke district), thus enabling prospectors to confine their labours to the productive zones only. The investigation applied mainly to the pre-Cambrian rocks, and it was found that the workable copper is chiefly restricted to certain igneous portions of these rocks. A petrographic subdivision of the pre-Cambrian strata into volcanic (copper-bearing) and sedimentary rocks was made in conformity with this discovery.

The completion of the study of the geology of certain parts of Charlotte County, New Brunswick, was undertaken by Dr. R. W. Ells. This work included the examination of the rocks of Grand Manan Island, and of portions of the shore of the Bay of Fundy, between Beaver Harbour and Point Lepreau, where, at different places, through the agency of intrusives, the ordinary sedimentary rocks of Silurian and Devonian age became altered to the condition of schists of pre-Cambrian aspect.

Professor L. W. Bailey was occupied in making geological investigations in New Brunswick (1) in the search for fossils in the pre-Carboniferous rocks of York and Carleton Counties, and (2) in obtaining information relating to the economic minerals of New Brunswick. The study of the fossils collected was intrusted to Dr. H. M. Ami, whose description of them forms an appendix to the report. Several species of graptolites from the black carbonaceous shales on the Tête à Gauche River, near Bathurst, Gloucester County, New Brunswick, were named, their facies suggesting an Ordovician fauna belonging to one of those zones of graptolites occurring on the St. Lawrence and Hudson Rivers. Some Brachiopods from the S.W. Miramichi River were too obscure for specific identity. Tracks of some organism, probably an annelid or other related form, were found at Tapley's Mill, Woodstock, New Brunswick, in an indurated slate; to this Dr. Ami gives a new generic and specific name—*Eugyrichnites minutus*. The geological origin of the slates is not determinable from the evidence at hand, but the new designation of the fossil is offered for the sake of reference.

Mr. Hugh Fletcher, with two assistants, continued field-work in Nova Scotia in the counties of Cumberland, Hants, King's, and Annapolis, including practical researches in the coalfields and iron-ore districts of those counties. A notable discovery was made by Mr. Fletcher, by whose advice a borehole was sunk to the depth of 2,340 feet, in the shape of a ten-foot seam of coal. This important piece of work opens at once a prospect of finding numerous workable coal-seams throughout a new area fifty miles in length by thirty in breadth.

A preliminary geological map of the Nictaux and Torbrook iron district of Annapolis County illustrates this report.

Mr. E. R. Faribault was engaged upon a special report on the goldfields of Eastern Nova Scotia; a general map of the gold-bearing rocks of the province from Canso to Yarmouth, and the granite areas, and a geological and structural map of the gold-bearing rocks of the eastern part of the province, from Isaac Harbour to Mount Uniacke. He is also preparing a bulletin on the occurrence of gold in Nova Scotia generally.

An interesting account by Mr. R. A. A. Johnston of a meteorite which fell August, 1904, near the village of Shelburne, Ontario, concludes the geological section of this report. The fragment, irregular and angular in form, weighed 12½ lbs., and was marked by the pittings and corrugations characteristic of many meteoric bodies. Another specimen which may or may not have formed part of the first was found not far from it, and was examined superficially by Mr. Johnston. This last weighed 28 lbs., and was found at a depth of about 2 feet from the surface of the ground, into which it had sunk in its fall. It is intended by its present owner to be sent to the University of Helsingfors, Finland. It would seem a matter for regret that this interesting specimen was not secured for the Museum at Ottawa.

Dr. G. C. Hoffmann gives a succinct account of the work done in the departments of Chemistry and Mineralogy. This was almost exclusively confined to the examination and analysis of such ores and minerals, etc., as were considered likely to prove of economic value. Following this is a summary by Mr. C. O. Senécal of the cartographical work accomplished under his supervision as geographer and chief draughtsman.

Dr. J. F. Whiteaves reports upon the work of the department of Palæontology and Zoology, and promises a fourth part of the "Palæozoic Fossils," to consist of the fossils of the Silurian rocks of Keewatin, Manitoba, and Saskatchewan contained in the museum. Mr. L. M. Lambe's work in vertebrate palæontology is also referred to.

A summary by Mr. E. D. Ingall and his staff of the mineral production of Canada in 1904 shows an aggregate value of over £12,000,000. The report concludes with four appendices consisting of (i) assays of ores referred to in Mr. Ingall's report; (ii) notes by Dr. Ami on some obscure fossils collected by Mr. Hugh Fletcher in Nova Scotia; (iii) description by Dr. Ami of a new species of *Bythotrephis* (*B. Yukonensis*) from the Yukon District; and (iv) determinations by Dr. Ami of fossil plants from British Columbia and the North-West Territories collected by Professor Penhallow of McGill University, Montreal.

This voluminous report, though only a summary of the work accomplished by the very efficient staff now carrying on the Survey, contains a vast amount of information relating to the physical resources of the Dominion, and indicates especially the great development that is taking place in mining in all its branches. A feature which greatly enhances the usefulness of the report is the number of maps that accompany it. We must also compliment the writers on the clearness as well as succinctness of their summaries. ARTHUR H. FOORD.

REPORTS AND PROCEEDINGS.

GEOLOGICAL SOCIETY OF LONDON.

The opening meeting of the Session was held at Burlington House on the evening of November 8th, 1905. J. E. Marr, Sc.D., F.R.S., President, in the chair.

The President announced that the Council at their meeting on June 28th last had passed the following resolutions :—

1. "The Council desire to record on their Minutes an expression of their deep regret at the death of their distinguished Treasurer, and of their grateful recognition of the loyal and effective services which for so long a series of years he has given to the Geological Society as Secretary, President, Treasurer, and Member of Council."

2. "That a copy of this resolution be forwarded to Mrs. Blanford, with an expression of the deep sympathy of the Council with herself and family."

The following communications were read :—

1. "The Coast-Ledges in the South-West of the Cape Colony." By Professor Ernest Hubert Lewis Schwarz, A.R.C.S., F.G.S.

The following coast-shelves have been recognized by the author in Cape Colony :—

NAME OF SHELF.	WESTERN. ft.	MIDLANDS. ft.	EASTERN. ft.	NATIVE TERRITORIES. ft.
Cyphergat........	5000–6000 ?	5000–6000 ?	5450 ?	—
Sterkstroom......	3500–4000 ?	4000 ?	4406 ?	4500 ?
Kentani...........	......	......	2500	2500
De Vlugt.........	1500	1000	1500	1500
Uplands	700	463	467	600
Bamboes Bay....	50–100	200	151	50–200
Sea-level	—	—	—	—
Agulhas	—600			

The most striking of these is the Upland shelf, which extends from Caledon to Port Elizabeth. It is cut by deep gorges into narrow ridges or 'ruggens,' but at a height the level tops of these ridges can be observed. The surface is in places covered with superficial deposits, cemented boulder-deposits, gravels, and sandy clays, hardened at the surface into ironstone or fresh-water quartzite. The author considers that this shelf cannot have been formed as a peneplain, but by marine denudation. On the 150–200 foot plateau there are deposits with marine shells, and in a depression on its top the evaporation of rain-water produces a large quantity of salt. The rock-shelf under the Cape Flats appears also to have been cut by the sea. The Agulhas Bank seems to consist of a succession of ledges, but it is not known whether further shelves extend beyond its margin. Taking the ledges together, the continent would appear to have been subject to lifts of 600 or 700 feet, with intermediate halts and set-backs. The author introduces the term 'absolute base-level of erosion' "to express the ocean-floor, including the shelf or level of erosion cut by the surf and off-shore currents that came near the water's edge when the depression of the present land-masses commenced." The author compares the shelves of Cape Colony with those described on the European and American sides of the North Atlantic, and he places the 'absolute base-level of erosion' at 12,000 feet in North America, 8,000 feet in Europe, and 1,200 feet in South Africa. With these varying heights he correlates the topography of the bordering continents—the sharp divides, open river-valleys, permanent rivers and deltas, of Europe and America, where the movement has been downward and has almost reached bottom, in contrast with the flat undenuded divides, the steep, narrow gorges, the waterfalls, and the rocky river-gates of South Africa, which is on the up-grade and probably near the top.

2. "The Glacial Period in Aberdeenshire and the Southern Border of the Moray Firth." By Thomas F. Jamieson, F.G.S.

One of the most interesting features in the Glacial geology of Aberdeenshire is the Red Clay found along the eastern coast of the county. It consists of red sediment brought by ice flowing along the coast from south to north, which also carries rocks from the coast between Montrose and Lunan Bay. The clay is sometimes finely laminated; at other times it is mixed with stones; and at times, again, contains esker-like mounds of gravel. It includes fragments of Crag-shells and of Mesozoic limestone. The purer masses of clay seem to have formed in a sheet of water lying in front of the ice, between it and the land, during the retreat of the Aberdeenshire ice, and at a time when the coast was submerged beneath water to a level exceeding 300 feet above the present coastline. Evidence of the northward motion of the ice is given from striæ, the transport and removal of flints, and the bending over of the edges of folia of gneiss. The red clay is underlain by a grey clay, and sometimes covered by a similar one. The author has recently discovered remains of a still older, dark indigo in colour, and containing small fragments of sea-shells. This has, however, been swept away in most places by subsequent ice-movement. In Banffshire a fine dark clay seems to have been formed under the same circumstances as the Red Clay of Aberdeenshire. The only evidence of warm intervals in this part of Scotland is that inferred from the melting away of the masses of ice, which preceded and followed the deposition of the Red Clay and the shell-beds of Clava.

On the southern border of the Moray Firth the author gives examples of glacial marking on the rocks, and refers to the transport of boulders, including a huge mass of Oolitic rocks 40 feet thick, a mass of clay once considered to be an outlier of Lias, 'pipe-rock,' and the fossiliferous Greensand débris at Moreseat, now considered to have been transported by ice. The ice appears to have been 4,000 to 5,000 feet thick about Inverness, in order to reach to and overflow Mormond in North-Eastern Aberdeenshire. The terraces of gravel found at decreasing heights on the Spey, near Rothes, seem to have been formed during stops in the retreat of the ice. Arctic shells of deep-water type, found in silt-beds south of Rattray Head, give evidence of a period of considerable submergence; but the recurrence of an ice-sheet appears to have destroyed most of this evidence, as is seen in a section at King Edward.

CORRESPONDENCE.

GEOLOGY OF DERBY, BURTON-ON-TRENT, ETC.

SIR,—Reading your review on the memoir of the Geological Survey, "The Geology of the Country between Derby, Burton-on-Trent, Ashby-de-la-Zouch, and Loughborough" (GEOL. MAG., September, p. 416), I notice that your reviewer has misread a very ambiguous statement, but I am surprised that he did not take exception to his own reading. The memoir states under the heading of Limestone Shales (which, by the way, in other publications members of the Survey have been calling Pendleside Series): "Both the limestone and shales are thinning out in this neighbourhood, and from attaining a thickness of 5,000 feet in Derbyshire are not more than 500 feet at Breedon"; with a footnote which says that even "this thickness is calculated on the supposition that there is not much Limestone hidden by the Trias." The Limestone Shales are stated to be 30 to 40 feet thick at Ticknall. Your reviewer, owing to the lack of capitals and general ambiguity, says the shales have thinned out from 5,000 feet in Derbyshire to some 500 feet at Breedon, when evidently the memoir means the whole Carboniferous Limestone and Pendleside Series. My chief object is to protest against the figures quoted for Derbyshire by the author of the memoir. I very gravely doubt that there are 3,000 feet of Limestone, and there certainly are not more than 800 to 1,000 feet of shales present in any continuous or unfaulted section.

Referring to the last paragraph on p. 75 of the second edition of the Survey memoir on North Derbyshire, which is quoted by Mr. Wedd on p. 9 of the Summary of Progress, 1904, I find the following:—"In the Mole-trap Mine 300 feet of shale were passed through before reaching the Limestone. The top of the shaft may be some 100 feet below the base of the Shale Grit, so that the Yoredale group will be here about 400 feet thick." This locality is near Cromford. Why the discrepancies between different publications of the Survey?

WHEELTON HIND.

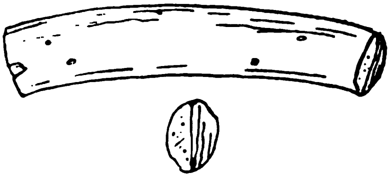
A REMARKABLE BONE FROM THE SUFFOLK CRAG.

SIR,—Will you permit me to ask whether any of your readers can tell what has become of the specimen of which I give a rough outline? I first saw it in 1865 in the extensive Crag collection of Mr. Whincopp at Woodbridge in Suffolk. It afterwards passed into the hands of Sir Joseph Prestwich, at whose house I again saw it in 1889, and then took the measurements from which my sketch is drawn.

I believe it used to be an adage of the Survey that "a note made at the time is worth a cartload of recollection." This was it:—"Dec. 21, 1865, at Mr. Whincopp's. The collection is large and unique. One of the most remarkable things is what he calls a 'bludgeon.' It is a piece of a fossil rib bone, and appears to have been mineralised in the Crag. It has been partially sawn across at both ends. The ends show incrustations of stalagmite, but stained ferruginous. The fractures look like those of recent bone, as if it had been broken off before it was mineralised."

At a subsequent visit, February 9th, 1866, I noted: "The fracture at one end is as much polished as the bone itself is, like all bones from the Crag; but at the other end decidedly less so. It was said to have been found with an urn."

Mr. Whincopp told me that the thing was brought to him by a carrier from the country, and seemed to have no definite information about it; but it was evidently a bone from the Red Crag, which was at the time largely worked for phosphatic nodules. The note which I made at Prestwich's house was this: "5th August, 1889. This specimen is now in the collection of Prof. Prestwich, where I saw it at this date. It weighs 2 lb. 7 ozs. The above is a fair representation of it" (now copied). The little pits on the surface are shallow excavations. Its length is 10½ inches and diameter 2 inches.



Scale, two inches to a foot.

Of course, the antecedent probability is against finding a specimen bearing signs of man's handiwork at such an early period as that of the Crag. But at every new stage to which his existence is pushed back there must always be a first find to break the record. The marine character of the Crag is not a serious objection, for, seeing that Mr. Whincopp's collection was remarkable for the large number of remains of land animals that it contained, there is no reason why, if man should have lived among them, one of his implements might not have been found along with their bones.

It is in the hope that this curious object may be brought to light, and examined by competent judges, that I venture to ask you to print this letter. O. Fisher.

Harlton, Cambridge, *October 1st*, 1905.

P.S.—Since writing the above I have met with the following memorandum, which I had overlooked: "Feb. 9, 1866. Mr. Whincopp's collection. The 'bludgeon,' which I particularly noticed when last here in December, is evidently formed from a fossil bone, a rib, but I think was a fossil before being made into a bludgeon."

The conclusion would be that it was cut off at one end before being mineralised, but that it was subsequently shortened to suit the requirement of some Neolithic man who had found it.

OBITUARY.

CAPT. FREDERICK WOLLASTON HUTTON, F.R.S., F.G.S.

Born November 16, 1836. Died October 27, 1905.

We regret to record the death of Capt. F. W. Hutton, F.R.S., Curator of the Canterbury Museum, Christchurch, New Zealand, on Friday, 27th October, at the age of 68, on board the R.M. s.s. "Rimutka," while on his return voyage from England to New Zealand, after a brief Summer visit to the old country.

F. W. Hutton was the second son of the Rev. H. F. Hutton, and was born at Gate Burton, Lincolnshire, 16th November, 1836. He was educated at the Southwell Grammar School, and later entered the Naval Academy at Gosport. Being over age when nominated for the Royal Navy, he served as a midshipman in the Indian Mercantile Marine. He joined the 23rd Royal Welsh Fusiliers in 1855, serving in the Crimea 1855–6; was in the relief of Lucknow under Lord Clyde; and took part in the capture of Lucknow, receiving the medal with two clasps. He entered the Staff College in 1860, passing out sixth on the list. Whilst stationed at Malta, in 1866, he communicated an excellent paper to the GEOLOGICAL MAGAZINE on the Geology of Malta (see Vol. III, pp. 145–152, and Pls. VIII and IX). More than twenty other papers are recorded to his credit in this journal, and eight in the Quarterly Journal of the Geol. Soc. Lond. In 1866 Capt. Hutton retired from the Army, and emigrated to New Zealand. At first he was attached as an Assistant Geologist to the Geological Survey of New Zealand in 1871; later on (1873) he was appointed Curator of the Otago Museum, and in 1877 Professor of Natural Science in the Otago University. In 1880 he was appointed Professor of Biology in the University of New Zealand, a post he held until 1893. He joined the Geological Society in 1861, was elected a Corresponding Memb. Zool. Soc. Lond. in 1872, and an F.R.S. in 1892. He was chosen President of the Australian Association for the Advancement of Science, 1901–2. He held for some years the post of Curator of the Canterbury Museum and Lecturer in Geology in Canterbury College, N.Z. He published a class-book of Elementary Zoology, 1879, and a large number of papers in the Transactions of the New Zealand Institute and other Scientific Societies at home and in the Colonies. He was an entomologist as well as a geologist; indeed, Capt. Hutton may be said to have been a good all-round naturalist and a very able scientific man.

Capt. Hutton married in 1863 the daughter of W. Montgomerie, M.D.

MISCELLANEOUS.

DIPLODOCUS CARNEGIEI. (Plate XXV.)

This huge Dinosaur (Pl. XXV) is one of the largest of ancient terrestrial animals, being 14 feet high and 80 feet in length. The head is very small, but the neck is extremely long and flexible. The teeth are confined to the front of the jaws, and are small and peg-like, and could only have served to collect the succulent vegetation on which the creature is supposed to have subsisted. The body is relatively short, but the length of the ribs and the massiveness of the limbs show it to have been of immense size and weight. The tail was of extraordinary length, and consisted of more than 70 vertebræ, being about half the total length of the animal. As the nostrils open quite on the top of the head, a position which would be particularly convenient to an air-breathing animal that lived under water, it has been suggested that it was probably semi-aquatic in its habits, living mostly at the bottom of shallow lakes and rivers, browsing on water-plants, and putting up its head to breathe.

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